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THE THELEPHORACEAE OF NORTH AMERICA. XI¹

TULASNELLA, VELUTICEPS, MYCOBONIA, EPITHELE, and
LACHNOCLADIUM

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TULASNELLA

Tulasnella Schroeter, Krypt.-Fl. Schlesien 3: 397. 1888;
Juel, K. Svenska Vet.-Akad. Bihang till Handl. Afd. III.
23¹²: 21. 1897; Arkiv för Bot. 14¹: 8. 1915; Sacc. Syll. Fung.
14: 234. 1899.—*Prototremella* Patouillard, Jour. de Bot. 2:
267. 1888.—*Pachysterigma* Johan-Olsen in Brefeld, Untersuch.
Myk. 8: 5. 1889; Engl. & Prantl, Nat. Pflanzenfam. (1: 1**):
117. 1898.

Fungi with the aspect of *Corticium* and with simple ovoid to globose basidia but having very large sterigmata, each of which bears a spore.

The organs which have the position of sterigmata—and are so called in the original definition of *Tulasnella* which I have followed—are different from all other sterigmata which I have seen by their spore-like form and greatly constricted connection with the body of the basidium as compared with the diameter of the rest of the sterigma. These organs resemble usual sterigmata in being permanently attached to their basidia. Juel, *loc. cit.*, gives cytological reasons for regarding these organs as basidiospores rather than as sterigmata, but basidiospores not sep-

¹ Issued March 2, 1920.

arable at maturity from the basidia which produce them are not known elsewhere in *Basidiomycetes*, so far as I am aware. Juel's material for cytological study proved to be the hymenium of a *Poria* infested by two species of *Tulasnella*. For the present, it seems less confusing in a taxonomic paper to refer to the spore-shaped organs permanently attached to the basidia in species of *Tulasnella* as sterigmata.

The specimens of *Tulasnella* which I have seen in vegetative condition were slightly colored in such colors as livid pink, dull lavender, and ecru-drab of Ridgway; specimens of all species fade to pale olive-gray in the herbarium. The spores were colored in the mass like the fructifications from which they were obtained in the cases where I secured spore falls on glass from specimens of my collection, but are hyaline under high magnification with the microscope. The fructifications are not adnate, as this term is applied to *Peniophora cinerea*, but merely very thin and tender, for when they are moistened small portions sufficiently large for crushing under a cover glass may be lifted clean from the substratum with the point of a scalpel. Such portions spread out well under the cover glass upon application of pressure and are very satisfactory for observation of the spores and sterigmata.

The species of *Tulasnella* are so similar in aspect that one has to rely upon microscopic details—chiefly of the spores and sterigmata—for recognition of the species. Nineteen species of *Tulasnella* are listed for Europe, but upon such slight differences in dimensions of the spores that it seems probable that the number will be materially reduced when a revision can be made upon the basis of first-hand knowledge of these species.

Tulasnella has been collected in North America in northern United States and Canada only; these gatherings are arranged in three species.

KEY TO THE SPECIES

- | | |
|--|-----------------------------|
| Spores subglobose, $3\frac{1}{2}$ –6 \times 3–4 μ | 1. <i>T. Eichleriana</i> |
| Spores subglobose, 5–9 \times 4 $\frac{1}{2}$ –6 μ | 2. <i>T. violacea</i> |
| Spores more elongated, 10–15 \times 3–5 μ | 3. <i>T. fusco-violacea</i> |

1. *Tulasnella Eichleriana* Bresadola, Ann. Myc. 1: 113. 1903; Sacc. Syll. Fung. 17: 209. 1905; Bourdot & Galzin, Soc. Myc. Fr. Bul. 25: 32. 1909; Juel, Arkiv för Bot. 14: 8. 1915.

Fructification effused, thin, pale lilac, finally fading to olive-buff; in structure 20–60 μ thick, composed of interwoven, hyaline hyphae 3 μ in diameter; sterigmata 7–10 \times 3½–4½ μ ; spores hyaline, even, 3½–6 \times 3–4 μ .

Fructifications 3–6 \times 1–1½ cm.

On rotting wood and bark of frondose species, rarely on coniferous substrata. Canada, New Hampshire, New York, Idaho, and Washington. July to November.



Fig. 1. *T. Eichleriana*. Young basidium, a, beginning formation of sterigmata; older basidium, b, having full-grown sterigmata; collapsed basidium, c, with spore attached to one sterigma; sterigma, d, bearing a spore; spores, s; hypha, h. \times 870.

T. Eichleriana is noteworthy by having the smallest spores and sterigmata which are known in the genus. In these details American collections agree so closely with those of European specimens of *T. Eichleriana* that one can hardly doubt their being this species although authentic specimens have not been at hand for verification.

Specimens examined:

Canada: J. Macoun, 21.

Ontario: Ottawa, J. Macoun, 13.

New Hampshire: Chocorua, W. G. Farlow, 1, 4, 6**, and two unnumbered specimens (the last three specimens in Mo. Bot. Gard. Herb., 55270, 55276, and 55597), and Nos. A and C (in Farlow Herb.).

Massachusetts: Sharon, A. P. D. Piguet, B, E (in Farlow Herb.).
New York: Ithaca, comm. by G. F. Atkinson, 2817.
Idaho: Priest River, J. R. Weir, 391 (in Mo. Bot. Gard. Herb., 15657).
Washington: Chehalis C. J. Humphrey, 6284.

2. *T. violea* (Quelet) Bourdot & Galzin, Soc. Myc. Fr. Bul. 25: 31. 1909.

Hypochnus violeus Quelet, Ass. Fr. Av. Sci. 1882: 401. 1883.
—*Prototremella Tulasnei* Patouillard, Jour. de Bot. 2: 270. text f. 1-3. 1888; Essai Taxon. Hym. 27. text f. 19. 1900; Sacc. Syll. Fung. 9: 236. 1891.—*Tulasnella Tulasnei* (Patouillard) Juel, K. Svenska Vet.-Akad. Bihang till Handl. Afd. III. 23¹²: 21. 1897; Arkiv för Bot. 14¹: 8. 1915; Sacc. Syll. Fung. 14: 234. 1899; Bresadola, Ann. Myc. 1: 114. 1903.—*T. incarnata* Bourdot & Galzin, Soc. Myc. Fr. Bul. 25: 31. 1909.—*An Corticium incarnatum* var. *pinicolum* Tulasne, Ann. Sci. Nat. Bot. V. 15: 227. pl. 10. f. 3-5. 1872?—Not *Pachysterigmata incarnata* Johan-Olsen in Brefeld, Untersuch. Myk. 8: 7. pl. 1. f. 1-2. 1889.—Not *Corticium roseolum* Karsten, Soc. pro Fauna et Fl. Fenn. Meddel. 16: 2. 1888.

Illustrations: Patouillard, loc. cit.

Type: specimens determined by Quelet in Bourdot Herb. and a fragment in Burt Herb.

Fructification effused, thin, livid pink to dull lavender, fading in the herbarium to olive-buff; in structure 30-70 μ thick, composed of interwoven hyaline hyphae 3 μ in diameter; sterigmata 7-10 \times 5-6 μ , with the main portion nearly spherical; spores subglobose, even, 5-9 \times 4 $\frac{1}{2}$ -6 μ .

Fructifications 1 $\frac{1}{2}$ -6 cm. long, 1-3 cm. broad.

On wood and fallen branches of frondose species, rarely on pine. New England, New York, and Washington. March to November.

This species is distinguished from *T. Eichleriana* by larger spores and sterigmata. The spores are usually about 6 \times 5 μ , with a slight point of attachment at the base; the body portion of the sterigma has about the same dimensions as the spores. The fructifications are too thin and tender to permit of large

portions being separated from the substratum, but they are not adnate, for upon moistening the fructification small portions large enough for preparation under a cover glass may be lifted from the substratum with the point of a scalpel.

It seems probable that *Corticium incarnatum* var. *pinicolum* Tul. must have been either the present species or *T. Eichleriana*, on account of the subglobose spores which the Tulasnes figured, although unfortunately without stating spore dimensions or scale of magnification of their figures.

Von Höhnelt & Litschauer have published¹ that *Corticium roseolum* Karst. is the same species as *Tulasnella Tulasnei*. I have studied an authentic specimen of *C. roseolum* communicated to me by Karsten; this species is not distinguishable in



Fig. 2. *T. violea*. Young basidium, y; young basidium, a, forming sterigmata; basidium, b, with nearly full-grown sterigmata; old, collapsed basidium, c, from whose sterigmata the spores have fallen; spores, s. $\times 870$. From specimen determined by Quelet.

coloration and aspect from several sendings of *T. Tulasnei* (= *T. violea*), also on *Betula*, received from Romell and cited below, but it is entirely different in microscopic characters. This specimen of *C. roseolum* agrees well with the description published by Karsten; its spores are hyaline, even, $4-6 \times 3-3\frac{1}{2} \mu$, borne 4 to a basidium on very slender sterigmata of the usual *Corticium* kind; the basidia are simple, cylindric or clavate, $9-10 \times 4-4\frac{1}{2} \mu$; the hyphae are sometimes nodose-septate, and some are incrustated in the region of the substratum. Karsten's publication of *Corticium roseolum* antedates that by Massee and renders unnecessary *Corticium subroseum* Sacc. & Syd. in Sacc. Syll. Fung. 14: 223. 1899.

¹ K. Akad. Wiss. Wien, Sitzungaber. 115: 1557. 1906.

Specimens examined:

Sweden: Stockholm, *L. Romell*, 125, 141, 142, 143, 149, 150, 184.

Austria-Hungary: Sonntagberg, *Strasser*, comm. by Bresadola under the name *T. incarnata*.

France: Aveyron, *A. Galzin*, comm. by H. Bourdot, 15423; Allier, *H. Bourdot*, 1798, determined by Quelet, and 3765 under the name *T. incarnata*.

New Hampshire: Chocorua, *W. G. Farlow*.

Vermont: Little Notch, Bristol, *E. A. Burt*; Middlebury, *E. A. Burt*; Chapman's Mill, Middlebury, *E. A. Burt*.

Massachusetts: Magnolia, *W. G. Farlow* (in Farlow Herb.); Sharon, *A. P. D. Piguet*, comm. by W. G. Farlow, N (in Mo. Bot. Gard. Herb., 55002); Sherborn, *H. P. Morse*, comm. by W. G. Farlow; Waltham, *W. G. Farlow* (in Farlow Herb.).

New York: East Galway, *E. A. Burt*.

Washington: Bingen, *W. N. Suksdorf*, 906.

3. *T. fusco-violacea* Bresadola, *Fungi Tridentini* 2: 98. pl. 210. f. 1. 1900; Sacc. *Syll. Fung.* 16: 203. 1902; Bourdot & Galzin, *Soc. Myc. Fr. Bul.* 25: 31. 1909; Juel, *Arkiv för Bot.* 14: 8. 1915.

Illustrations: Bresadola, *Fungi Tridentini* 2: pl. 210. f. 1.

Type: authentic specimen in Burt Herb.

Fructification effused, thin, ecru-drab, fading to pale smoke-gray and pale olive-gray in the herbarium; in structure 40–60 μ thick, composed of hyaline, interwoven hyphae 4–5 μ in diameter; sterigmata 12–15 \times 4½–6 μ ; spores hyaline under the microscope, even, 10–15 \times 3–5 μ .

Fructifications 3–5 cm. in diameter.

On bark of *Abies* and sometimes of frondose species. New Hampshire to Pennsylvania. August to December. Rare.

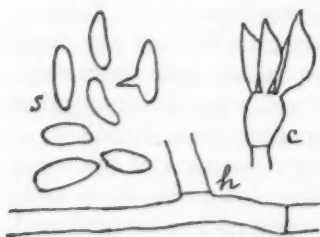


Fig. 3. *T. fusco-violacea*. Basidium, c, with fully developed sterigmata; spores, s; hypha, h. \times 870. From authentic specimen from Bresadola. One spore shows a curious projection.

T. fusco-violacea is distinguished from the other species hitherto found in North America by having slender and elongated, rather than subglobose, spores. Bresadola described the color of the fructification as fusco-violaceous when in vegetative condition, drying lilacinus; I have seen dried specimens only, and that from Bresadola is now pale smoke-gray.

Specimens examined:

Sweden: Femsjö, *L. Romell*, 418.

Tyrol: Cavallente, *G. Bresadola*.

New Hampshire: Crawford Notch, *L. O. Overholts*, 4883 (in Mo. Bot. Gard. Herb., 56076).

Pennsylvania: Trexlertown, *W. Herbst*, 53.

VELUTICEPS

Veluticeps Cooke emend. Patouillard, Soc. Myc. Fr. Bul. 10: 78. pl. 3. f. 1. 1894; Cooke, Grevillea 8: 148. 1880 (in part).—*Veluticeps* as a section of *Hymenochaete* Masee, Linn. Soc. Bot. Jour. 27: 116. 1890; not of Sacc. Syll. Fung. 6: 600. 1888.

Hymenium velvety with fascicles of colored, flexuous hyphae.

The type species is *Veluticeps Berkeleyi* Cooke, which was published originally as *Hymenochaete veluticeps* Berk. & Curtis.

The fructifications are pileate in the species best known; either dimidiate in our single Cuban species or sessile and attached by the vertex in the species occurring on the opposite side of the world in New South Wales. In both species the fascicles of colored hyphae are 800 μ or more long, about 40–60 μ in diameter, and traverse the whole or a large part of the fructification perpendicular to the surface of the hymenium, beyond which they protrude up to 40–100 μ . The colored hyphae composing the fascicles are about 4½ μ in diameter, cylindric, sometimes granule-incrusted—especially in the deeper portions of the fructification—and are closely crowded together, perhaps 20 or more to a fascicle; they have the character of the colored cystidia, which are scattered between the basidia in the hymenium of *Stereum abietinum*, *S. glaucescens*, and *S. abnormis*, rather than of the conical, pointed setae characteristic of species of *Hymenochaete*. The genera *Mycobonia* and *Epithele* are closely related to *Veluticeps* by fascicles of hyphae protruding

from the hymenium, but have the fascicles composed of hyaline hyphae.

Veluticeps Berkeleyi Cooke, *Grevillea* 8: 149. 1880; Patouillard, *Myc. Soc. Fr. Bul.* 10: 77. *pl. 3. f. 1.* 1894.

Hymenochaete veluticeps Berk. & Curtis, *Linn. Soc. Bot. Jour.* 10: 333. 1868; Sacc. *Syll. Fung.* 6: 600. 1888; Massee, *Linn. Soc. Bot. Jour.* 27: 116. 1890.

Illustrations: *Myc. Soc. Fr. Bul.* 10: *pl. 3. f. 1.*

Type: in Kew Herb. and in Curtis Herb.

Fructification dimidiate, coriaceous, hard and brittle, on the upper side brown, sulcate-zonate, velutinous, becoming glabrous; hymenium pallid cinnamon, plane, thickly studded with pro-

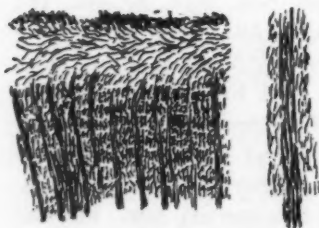


Fig. 4. *V. Berkeleyi*. Section of fructification at left, showing hyphal fascicles, $\times 19$; at right, a single fascicle, $\times 90$.

truding fascicles of very dark hyphae; in structure 1-2 mm. thick, composed throughout of colored hyphae arranged in three layers, a broad intermediate layer of longitudinally arranged hyphae which turn upward on the upper side to form the velutinous surface layer and turn downward on the opposite side and terminate in the hymenium; bister-colored hyphal fascicles 40-60 μ in diameter, 800 μ or more long, extend

through the under layer of tawny olive subhymenial hyphae and protrude up to 40-60 μ beyond the basidia; spores not found.

On logs in woods, often on the under side. May, July. Cuba.

V. Berkeleyi may be recognized by its aspect of a *Hydnum* which upon close examination shows its teeth-like projections on the hymenial side to be really hyphal fascicles not covered by the hymenium. The spores were found to be ovoid and hyaline by Patouillard. Six collections of this species by C. Wright are reported by Berkeley & Curtis in *Fungi Cubenses*, from which it would seem that the species is common, but I have been able to see no more recent collections from any source. It is possible

that my correspondents have roughly classified their collections of this species as a *Hydnum* and withheld specimens of it.

Specimens examined:

Cuba: *C. Wright*, 264 (in Curtis Herb.).

In working over the species of *Aleurodiscus* which have been described, I found that the *Aleurodiscus tabacinus* Cooke should be transferred to *Veluticeps*. Although the species is extra limital and not likely to be found in North America, I now make this transfer and add the following notes on structure:

Veluticeps tabacina (Cooke) Burt, n. comb.

Aleurodiscus tabacinus Cooke, *Grevillea* 14: 11. 1885; Handb. Australian Fungi, 193. 1892.—*Corticium tabacinum* (Cooke) Sacc. Syll. Fung. 6: 607. 1888.

Fructifications pileate, hemispherical or cup-shaped, sessile, apparently attached by the vertex, drying nearly black; in structure 800 μ thick, with a nearly black, crust-like zone on the upper side, from which a broad layer of hyaline hyphae extends to the hymenium and is traversed by brown hyphal fascicles; hymenium drying Verona brown, not covering the protruding fascicles; fascicles about 6 to a mm., 50–60 μ in diameter, up to 900 μ long, protruding up to 100 μ beyond the hymenium, composed of flexuous, colored hyphae 3 μ in diameter; basidia simple, 100 \times 9–10 μ , bearing the spores on 4 slender sterigmata; spores hyaline, even, flattened on one side, 16 \times 6 μ .

Fructifications 2–3 mm. in diameter, 1–1½ mm. thick.

On wood. New South Wales.

V. tabacina is distinct from *V. Berkeleyi* by attachment of its pileus by the center, and by its hyaline substance and sub-hymenial tissue; when a fertile specimen of *V. Berkeleyi* is available, a difference in spores may perhaps be found.

Specimens examined:

Australia: New South Wales, comm. by G. Massee (in N. Y. Bot. Gard. Herb.).

MYCOBONIA

Mycobonia Patouillard, Myc. Soc. Fr. Bul. 10: 76. 1894
(with diagnosis under *Bonia* Patouillard, Myc. Soc. Fr. Bul. 8:

48. 1892, but not *Bonia Balansa*).—*Grandinioides* Banker, Torr. Bot. Club Mem. 12: 179. 1906.

Thelephoraceous fungi having the hymenium bristling with short cylindric fascicles of hyaline hyphae which arise from the subhymenial tissue.

The type species is *Mycobonia flava*.

Patouillard intended at first that this genus should include both resupinate and pileate species, but he soon transferred the known resupinate species to *Heterochaete* on account of the longitudinally septate basidia. A few years later he introduced *Epithele* in connection with resupinate species, having hyphal fascicles like those of *Mycobonia flava*.

KEY TO THE SPECIES

- Fructification sessile 1. *M. flava*
Fructification stipitate 2. *M. brunneoleuca*

1. *Mycobonia flava* (Swartz) Patouillard, Myc. Soc. Fr. Bul. 10: 76. pl. 3. f. 2. 1894; *Ibid.* 16: 180. 1900.

Hydnum flavum Swartz ex Berkeley, Ann. & Mag. Nat. Hist. 1. 10: 380. pl. 10. f. 8. 1842; Linn. Soc. Bot. Jour. 10: 324. 1868; Sacc. Syll. Fung. 6: 456. 1888.—*Peziza flava* Swartz, Prodr. 150. 1788; Fl. Ind. Oc. 3: 1939. 1806.—*Bonia flava* (Berk.) Patouillard in Engl. & Prantl, Nat. Pflanzenfam. (1. 1**): 123. text f. 68G-H. 1898.—*Grandinioides flavum* (Swartz) Banker, Torr. Bot. Club Mem. 12: 179. 1906.

Illustrations: Ann. & Mag. Nat. Hist. 1. 10: pl. 10. f. 8; Myc. Soc. Fr. Bul. 10: pl. 3. f. 2; Engl. & Prantl, Nat. Pflanzenfam. (1. 1**): text f. 68 G-H.

Type: in British Mus. Herb. according to Berkeley, loc. cit.

Fructification coriaceous, convex, somewhat orbicular to reniform, sessile, attached by a point on one side, even, glabrous, drying ochraceous buff to cinnamon; hymenium ochraceous buff, with numerous short hyphal fascicles suggesting the teeth of a *Hydnum*; fascicles cylindric, 5-6 to a mm., 60-120 × 40-60 μ, composed of hyaline or subhyaline hyphae; basidia simple, clavate, 30 × 6-7½ μ; spores hyaline, even, 10-16 × 6 μ, not seen attached to the basidia.

Fructifications 1-3 cm. long, 1½-3 cm. broad.

On fallen branches and old logs. Florida, Louisiana, Jamaica, West Indies, and Venezuela. August to November.

When examined by the naked eye or with a magnifying glass, *M. flava* is not distinguishable from a *Hydnum*, but when sections are examined with the compound microscope, the hymenium is found to be a plane surface pierced here and there by the protruding fascicles of hyphae. The spore dimensions are those of spores which were on the surface of the hymenium. A specimen in the collection from Florida has a stem 1 mm. long, but the spores are $13 \times 6\frac{1}{2} \mu$ and other characters such that I refer the collection to *M. flava*.

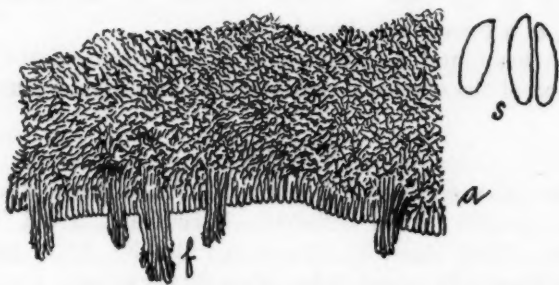


Fig. 5. *M. flava*. Section of fructification, *a*, showing hyphal fascicles, *f*, $\times 90$; spores, *s*, $\times 870$.

Specimens examined:

Florida: Cocoanut Grove, *R. Thaxter* (in Mo. Bot. Gard. Herb., 43985).

Louisiana: St. Martinville, *A. B. Langlois*.

Cuba: *C. Wright* (in Curtis Herb.); Guantonamo (in Weir Herb., 10849); Pinar del Rio San Diego de los Baños, *N. L. Britton*, *F. S. Earle* & *C. S. Gager*, 6823 (in N. Y. Bot. Gard. Herb., Burt Herb., and Mo. Bot. Gard. Herb., 56075); Puerto Principe, *F. S. Earle*, 312.

2. *M. brunneoleuca* (Berk. & Curtis) Patouillard, Myc. Soc. Fr. Bul. 16: 181. 1900; Duss, Fl. Crypt. Antilles Fr. 233. 1903.

Hydnum brunneoleucum Berk. & Curtis, Linn. Soc. Trans. 22: 129. 1857; Linn. Soc. Bot. Jour. 10: 325. 1868; Sacc. Syll.

Fung. 6: 457. 1888.—*Grandinioides flavum* (Swartz) Banker, Torr. Bot. Club Mem. 12: 179. 1906 (in part).

Type: in Kew Herb. and Curtis Herb.

Pileus helmet-shaped to flabelliform, vaulted, thin, yellowish brown, slightly streaked behind, glabrous; stem very short, brownish; hymenium whitish, sprinkled with many scattered strong bristles.

Pileus 3½–4 cm. long, nearly as broad.

On dead wood. Martinique and Venezuela.

Patouillard has noted in the place cited that the pileus may attain a diameter of 15 cm., and that the stem is short, thick, and black at the base. Banker includes *M. brunneoleuca* in *M. flava* as a poorly developed form.

I have examined no specimens of *M. brunneoleuca*. The description of the species is that given by Berkeley & Curtis.

EPITHELE

Epithele (as a section of *Hypochnus*) Patouillard, Myc. Soc. Fr. Bul. 15: 202. 1899.—*Epithele* Patouillard, Essai Taxon. Hym. 59. 1900; Duss, Fl. Crypt. Antilles Fr. 226. 1903; v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungsber. 115: 1595. 1906; Bourdot & Galzin, Soc. Myc. Fr. Bul. 27: 264. 1911.

Resupinate thelephoraceous fungi lacking an intermediate layer and having the hymenium bristling with short cylindric fascicles of hyaline hyphae which arise from the subhymenial tissue.

The type species is *Epithele Dussii*.

The four species of *Epithele*, known at present, are very thin and delicate in structure and constitute a natural group which is not connected with *Mycobonia* by thick resupinate species with either an intermediate layer or with a doubtful intermediate layer—doubtful merely because the hyphae are interwoven rather than arranged longitudinally in the region of the intermediate layer. *Epithele Typhae* (Pers.) Pat. is a frequent species in Europe on dead leaf bases of *Typha*; if present in the United States, it may have been regarded as one of the *Hydnaceae* on account of the hyphal fascicles in the hymenium.

KEY TO THE SPECIES

- Fructification elliptical, white; spores $6-7 \times 2\frac{1}{2}-3 \mu$; on tree fern 1. *E. Dussii*
 Fructification interruptedly effused, sulphur-yellow; spores $9-12 \times 7-9 \mu$; on
 palmetto 2. *E. sulphurea*

1. *Epithele Dussii* Patouillard, Essai Taxon. Hym. 59. 1900;
 Duss, Fl. Crypt. Antilles Fr. 226. 1903.

Hypochnus Dussii Patouillard, Myc. Soc. Fr. Bul. 15: 202.
 1899; Sacc. Syll. Fung. 16: 197. 1902.—*Peniophora Dussii*
 (Patouillard) v. Höhn. & Litsch. K. Akad. Wiss. Wien Sitzungs-
 ber. 116: 749. text f. 2. 1907.

Fructification resupinate, very thin, strongly adhering, forming a coating well defined, white or whitish, $3-15 \times 3-4$ mm.; fascicles very numerous, erect, white, $20-25 \mu$ in diameter, protruding up to 100μ , composed of hyphae; basidia 2- or 4-spored, $13 \times 6 \mu$; spores hyaline, even, attenuated towards the apex, $6-7 \times 2\frac{1}{2}-3 \mu$; layer between hymenium and substratum about 20μ thick.

On dead trunks of tree ferns. Guadeloupe and Venezuela.

The type, which I have not seen, was collected on the dead trunk of *Alsophila aspera*. The collection from Venezuela, cited below, although lacking spores, has the characteristic hyphal fascicles of *Epithele Dussii* and agrees well with Patouillard's description except in being broadly effused. This specimen is 10 cm. long, $1\frac{1}{2}$ cm. wide, and broken off with the substratum along one side and at both ends; hence the fructifications probably become long and widely effused.

Specimens examined:

Venezuela: Mt. El Val, A. F. Blakeslee, J2, comm. by W. G. Farlow (in Mo. Bot. Gard. Herb., 13614).

2. *E. sulphurea* Burt, n. sp.

Type: in Farlow Herb. and Mo. Bot. Gard. Herb.

Fructifications resupinate, interruptedly effused, drying pale sulphur-yellow to marguerite-yellow; in structure 300μ thick, composed of loosely interwoven, thick-walled, hyaline hyphae $2-3 \mu$ in diameter; fascicles about 9 to a mm., $15-30 \mu$ in diameter, protruding up to 100μ , composed of hyaline hyphae; basidia

simple, 8-10 μ in diameter, 4-spored; spores hyaline, even, 9-12 \times 7-9 μ .

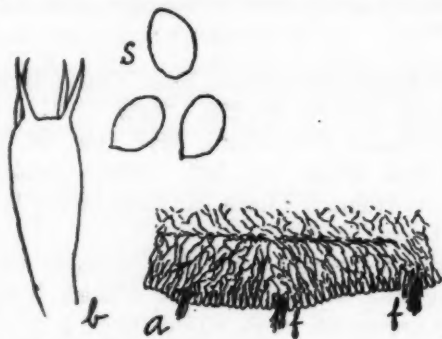


Fig. 6. *E. sulphurea*. Section of fructification, a, showing hyphal fascicles, f, $\times 19$; basidium, b, and spores, s, $\times 650$.

On palmetto. Florida. Autumn.

E. sulphurea is noteworthy by its greenish yellow color and spores much larger than those of other species of this genus. Collections of this species are likely to be included in *Hydnum* or *Odontia*, unless examination of sectional preparations is made with the microscope to show that teeth covered by the hymenium are not present.

Specimens examined:

Florida: Palm Beach, R. Thaxter, 52, type (in Farlow Herb. and in Mo. Bot. Gard. Herb., 43940).

LACHNOCLADIUM

Lachnocladium Léveillé in d'Orbigny, Dict. Hist. Nat. 8: 487. 1846; Morgan, Cincinnati Soc. Nat. Hist. Jour. 10: 192. 1888; Sacc. Syll. Fung. 6: 738. 1888; Patouillard, Jour. de Bot. 3: 23. pl. 1. 1889; Engl. & Prantl, Nat. Pflanzenfam. (1: 1**): 137. 1898.—*Eriocladius* Léveillé, Ann. Sci. Nat. Bot. III. 5: 158. 1846, but not of Lindley.

Fructifications coriaceous or somewhat coriaceous, branched, tomentose; branches compressed or terete; coralloid fungi growing on wood or on the ground.

This genus was founded upon a group of seven species, of which none was designated as the type species.

The distinctive characters of *Lachnocladium* are coriaceous consistency and more or less hairy covering of fructifications; by these characters the genus is distinguished from *Clavaria*. At the time of publication of *Lachnocladium* under the name *Eriocladius*, as first proposed, Lévillé restricted the Persoonian genus *Merisma* to glabrous, coriaceous, branched species of the *Clavariaceae*. He had *Clavaria* include fleshy species only, *Merisma*, the glabrous coriaceous species, and *Lachnocladium*, tomentose species so tomentose that the branches were tomentose. Mycologists have not accepted *Merisma* as understood by Lévillé; they have transferred to *Pterula* most of the species which Lévillé had in *Merisma*, and have by their usage modified the idea of *Lachnocladium* by publishing as members of this genus many species which do not have their branches tomentose but differ from branched species of *Clavaria* by being coriaceous.

Lachnocladium comprises a series of species parallel with *Clavaria*; some of the species have hyaline spores, others have more or less ochraceous spores, some, even spores, and some, rough-walled to aculeate spores. Species with dark-colored, more or less rough-walled to muricate spores are better referable to *Thelephora*.

Lévillé regarded *Lachnocladium* as one of the *Clavariaceae* and the genus is located there in Saccardo's 'Sylloge Fungorum' and by Hennings in Engler & Prantl's 'Nat. Pflanzenfam.' Berkeley & Curtis arranged the species of *Lachnocladium* between those of *Thelephora* and *Stereum* in their 'Notices of North American Fungi' and 'Fungi Cubenses.'² Patouillard includes *Lachnocladium* in his series of *Thelephores*. In North America there are no species connecting, or intermediate between, *Lachnocladium* and *Thelephora*. While I have had no opportunity to study the various exotic species with dark-colored, echinulate spores which have been published as *Lachnocladium*, it seems very probable that the transfer of such species to *Thelephora* near *Thelephora anthocephala* would

¹ Grevillea 1: 161. 1873.

² Linn. Soc. Bot. Jour. 10: 330. 1868.

leave the remaining species of *Lachnocladium* clearly in the *Clavariaceae*.

I include *Lachnocladium* for reference by students of the *Thelephoraceae* because some authors have regarded it as a member of the latter family.

Collectors' field notes on whether the species are coriaceous or fleshy at the time of collecting are necessary for sharply separating *Lachnocladium* and *Clavaria*, for it is evident that these characters may not be well shown in the case of dried specimens of some species.

KEY TO THE SPECIES

- Spores hyaline 1
- Spores more or less ochraceous 4
- Spores dark-colored; in Guadeloupe 11. *L. guadelupense*
- 1. Spores ovoid or cylindric 2
- 1. Spores subglobose 3
- 2. Spores even, $3-4\frac{1}{2} \times 2-2\frac{1}{2} \mu$; radiately branched organs like those of *Asterostroma* present; Cuba to Brazil 1. *L. brasiliense*
- 2. Spores even, $9 \times 6 \mu$; fructification somewhat cartilaginous; in Cuba 2. *L. cartilagineum*
- 2. Spores even, $6-12 \times 3-3\frac{1}{2} \mu$; fructification dry, 2½-4 cm. high; on rotting leaves, Vermont to Ohio 3. *L. Micheneri*
- 2. Spores even, $12-15 \times 5-6 \mu$; fructification 3-4 cm. high, everywhere clothed with whitish down; in Pennsylvania 4. *L. semivestitum*
- 2. Spores $7-10 \times 2\frac{1}{2}-4\frac{1}{2} \mu$; fructifications 8 cm. high; on wood; Connecticut 12. *L. odoratum*
- 3. Spores even, $3-3\frac{1}{2} \times 2\frac{1}{2}-3 \mu$; fructification 2½ cm. high; on the ground, New Jersey and Pennsylvania 5. *L. subsimile*
- 3. Spores even, $3\frac{1}{2}-4\frac{1}{2} \mu$ in diameter; fructification 4 cm. high; on wood, Cuba 6. *L. cervinum*
- 3. Spores even, $9\frac{1}{2} \times 8-9 \mu$; on the ground, New Hampshire, Massachusetts, and New York 7. *L. bicolor*
- 4. Spores even, $7-12 \times 4\frac{1}{2}-6 \mu$; fructification velvety, ochraceous-ferruginous, 7-12 cm. high; on rotten wood, South America 8. *L. furcellatum*
- 4. Spores even, $6-7 \times 3-3\frac{1}{2} \mu$; fructification drying drab, clothed with a gray down, 8 cm. high; on wood, West Virginia 9. *L. erectum*
- 4. Spores even, $9-10 \times 4\frac{1}{2}-5\frac{1}{2} \mu$; stem 1 cm. in diameter; branch portion 6-7 cm. high, 5-6 cm. broad; North Carolina 10. *L. Atkinsonii*

1. *Lachnocladium brasiliense* Lévillé, Ann. Sci. Nat. Bot. III. 5: 159. 1846 (*Eriocladus*); Berk. & Curtis, Linn. Soc. Bot. Jour. 10: 330. 1868; Sacc. Syll. Fung. 6: 738. 1888; Patouillard, Jour. de Bot. 3: 26. pl. 1. f. 5. 1889. Plate 5, fig. 1. Illustrations: Patouillard, loc. cit.

Type: stated by Lévillé to be in De Candolle Herb.; Patouillard notes a specimen of original locality and collector—Bahia, Blanchet—in Museum of Paris Herb.

Fructification very short-stipitate, most highly branched, coriaceous, drying to tawny olive; branches solid, terete, dichotomous, with slender acute tips; spores hyaline, even, $3-4\frac{1}{2} \times 2-2\frac{1}{2} \mu$; borne on simple basidia; underneath the hymenium radiately branched organs like those of *Asterostroma*, pale-colored, with slender, flexuous rays up to $30 \times 3 \mu$, are abundant



Fig. 7. *L. brasiliense*. Antler-shaped and star-shaped organs, a; spores, s. $\times 870$.

and form the outer part of the medullary part of the branches and the somewhat spongy outer surface of the fructification where the hymenium is absent.

Fructifications 3–5 cm. high, about 3 cm. in diameter.

On rotting wood. Cuba to Brazil.

L. brasiliense is distinguished by its small, hyaline spores and by the brownish, antler-shaped and star-shaped organs, the latter suggestive of those of *Asterostroma*, which are abundant underneath the hymenium and form the sterile surface elsewhere.

Specimens examined:

Cuba: *C. Wright* (in Curtis Herb., under the name *Thelephora brasiliensis* Lév.); *C. Wright*, 831, under the name *Lachnocladium furcellatum* (in Curtis Herb. and in Mo. Bot. Gard. Herb., 43838).

2. *L. cartilagineum* Berk. & Curtis, Linn. Soc. Bot. Jour. 10: 330. 1868; Sacc. Syll. Fung. 6: 739. 1888; Patouillard, Jour. de Bot. 3: 26. pl. 1. f. 4. 1889. Plate 5, fig. 2.

Illustrations: Patouillard, loc. cit.

Type: in Kew Herb. and Curtis Herb.

Fructifications somewhat cartilaginous, erect, drying honey-yellow to olive-brown, densely and repeatedly branched above; branches cylindric, very sharp-pointed; stem slender, cylindric, strigose-hairy at the base; spores hyaline, even, $9 \times 6 \mu$, slightly flattened on one side, apiculate.

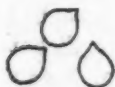


Fig. 8.
L. cartilagineum.
Spores, $\times 870$.

Fructifications 4 cm. high, 1–2½ cm. in diameter; stem 1½–2 cm. long, 1½–2 mm. in diameter.

On the ground. October. Cuba.

Patouillard has noted the spores of this species as ochraceous and a little smaller than I find them. The spores are very abundant in preparations from the type specimen, but the basidia are not well enough preserved to demonstrate whether simple or longitudinally cruciately septate.

Specimens examined:

Cuba: C. Wright, 204, type (in Curtis Herb.).

3. *L. Micheneri* Berk. & Curtis, *Grevillea* 1: 161. 1873; Morgan, *Cincinnati Soc. Nat. Hist. Jour.* 10: 192. 1888; Sacc. *Syll. Fung.* 6: 739. 1888; Hard, *Mushrooms*, 476. *text f.* 401. 1908.

Plate 5, fig. 3.

Clavaria fragrans Ell. & Ev. *N. Am. Fungi*, 2023. 1888. See Cooke, *Grevillea* 17: 59. 1889.—An *Lachnocladium odoratum* Atkinson, *Ann. Myc.* 6: 58; 1908?

Illustrations: Hard, *Mushrooms*, *text f.* 401.

Type: in Kew Herb. and Curtis Herb.

Fructifications gregarious, coriaceous, dry, repeatedly forked and branched and drying drab-gray above; stem cylindric, light buff, tomentose below, arising singly or in a few individuals from more or less effused, mycelial patches on decaying leaves; smaller branches filiform, flexuous, with paler tips; irregular, tomentose patches at various places on main trunk, branches, or axils of branches where hymenium has failed to develop; hymenium glabrous, no cystidia nor hairs present; spores hyaline, even, $6\text{--}12 \times 3\text{--}3\frac{1}{2} \mu$.

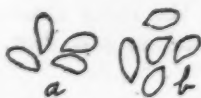


Fig. 9. *L. Micheneri*.
Spores, $\times 87$; a, from type;
b, from Burt coll.

Fructifications 2½–4 cm. high, 1–1½ cm. broad; main stem 2–3 mm. in diameter.

On rotting leaves in groves. Canada to New Jersey and westward to Missouri.

This species forms an orbicular, villose or mycelial patch on the surface of leaves—very often beech leaves—and from these patches arise one or two stems, which are tomentose below. In the field notes of this species I have the record, "bitter to taste," but the dried specimens are not bitter now.

Specimens examined:

Exsiccati: Ell. & Ev., N. Am. Fungi, 2023, type distribution of *Clavaria fragrans*; Ell. & Ev., Fungi Col., 1022.

Canada: Ontario, London, J. Dearness, in Ell. & Ev., Fungi Col., 1022.

Vermont: Newfane, C. D. Howe; Sudbury, E. A. Burt.

New York: Snyders, C. H. Peck (in N. Y. State Mus. Herb. and in Mo. Bot. Gard. Herb., 56113).

New Jersey: Newfield, J. B. Ellis, in Ell. & Ev., N. Am. Fungi, 2023.

Pennsylvania: E. Michener, 479, type (in Curtis Herb., 3534); Bethlehem, Schweinitz, the *Clavaria crispula* and *C. byssiseda* of Schweinitz, Syn. N. Am. Fungi, 1024 and 1034 respectively (in Herb. Schweinitz).

Ohio: C. G. Lloyd, 3817 (in Lloyd Herb., Burt Herb., Farlow Herb., and Mo. Bot. Gard. Herb., 44653); Oxford, L. O. Overholts, 1487 (in Overholts Herb.).

Missouri: Wickes, E. A. Burt (in Mo. Bot. Gard. Herb., 43813.)

4. *L. semivestitum* Berk. & Curtis, Grevillea 1: 161. 1873; Morgan, Cincinnati Soc. Nat. Hist. Jour. 10: 192. 1888; Sacc. Syll. Fung. 6: 739. 1888. Plate 5, fig. 4.

Type: in Kew Herb. and Curtis Herb.

Fructifications coriaceous, erect, repeatedly furcate-branched, the branches terete, rather straight, rising rather close together, everywhere clothed with whitish down except on the final branchlets, drying between light brownish olive and buffy brown; spores of the type hyaline, even, 12–15 × 5–6 μ.

Fructifications 3–4 cm. high, about 1 cm. in diameter across branches.

On the ground. Pennsylvania.

The fructifications of *L. semivestitum* probably occur solitary or gregarious on the ground. Distinguishing characters are slender, erect habit of growth, appressed branches, and large, hyaline, even spores. In the dried specimen the branches are pruinose rather than hairy. Cooke referred to *L. semivestitum* the specimens distributed by Ell. & Ev., N. Am. Fungi, 2024, under the name *Clavaria velutina* Ell. & Ev. without description, and Ellis & Everhart distributed in Fungi Col., 808, under the name *L. semivestitum* specimens growing on rotten wood

in West Virginia, but neither of these distributions can be *L. semivestitum*, for their spores are much too small.

Specimens examined:

Pennsylvania: *E. Michener*, 1184, type (in Curtis Herb., 4260).

5. *L. subsimile* Berk. Grevillea 1: 161. 1873; Sacc. Syll. Fung. 6: 739. 1888. Plate 5, fig. 5.

Type: in Kew Herb. and Curtis Herb.

Fructifications coriaceous, slender, delicately and repeatedly dichotomously branched, minutely tomentose except on the branchlets, drying between light brownish olive and buffy brown; spores hyaline, even, $3-3\frac{1}{2} \times 2\frac{1}{2}-3 \mu$.

Fructification $2\frac{1}{2}$ cm. high, $\frac{1}{2}$ cm. in diameter.

On ground in woods. New Jersey and Pennsylvania. September.

Fig. 11.
L. subsimile.
Spores, $\times 870$; a,
from type; b, from
Michener specimen
in Mo. Bot. Gard.
Herb.

L. subsimile in its dried condition has coloration and general aspect very like *L. semivestitum* but the branches of the former curve rather more apart at the axils and are not as closely appressed above. Only three spores were found in a preparation from the specimen in Curtis Herb., which may be rather immature; these spores are very small in comparison with those of *L. semivestitum*. The specimen distributed in Ell. & Ev., N. Am. Fungi, 2024, under the name *Clavaria velutina* E. & E., without description, and the collection from Pennsylvania, both

of which are cited below as *L. subsimile*, have their spores somewhat rough and may be specifically distinct from this species. Nevertheless I am inclined to regard both collections as the fully mature *L. subsimile*. The type of *L. subsimile* was published as Curtis Herb. No. 4600, which appears to be an error for 4690, the number borne by the specimen to which other data point as the specimen referred to by the description. Ellis notes for his distribution, "Milk white when fresh. Spores white."

Specimens examined:

Exsiccati: Ell. & Ev., N. Am. Fungi, 2024, under the name *Clavaria velutina*.

New Jersey: *Laning*, 49, probable type (in Curtis Herb., 4690); Newfield, J. B. Ellis, in Ell. & Ev., N. Am. Fungi, 2024.

Pennsylvania: *E. Michener* (in Mo. Bot. Gard. Herb., 56077).

6. *L. cervinum* (Berk. & Curtis) Patouillard, Jour. de Bot. 3: 26. 1888. Plate 5, fig. 9.

Clavaria cervina Berk. & Curtis, Linn. Soc. Bot. Jour. 10: 338. 1868; Sacc. Syll. Fung. 6: 716. 1888.—*Clavaria pallida* Berk. & Curtis, Linn. Soc. Bot. Jour. 10: 338. 1868; Sacc. Syll. Fung. 6: 714. 1888.—*Lachnocladium pallidum* (Berk. & Curtis) Patouillard, Jour. de Bot. 3: 26. 1888.

Type: in Kew Herb. and Curtis Herb.

Fructifications coriaceous, branched, becoming tawny olive in the herbarium, hairy with hyaline, thin-walled hairs $1\frac{1}{2}\mu$ in diameter which protrude 10μ beyond the basidia and are longer on the stem; branches repeatedly forked, slender, with very acute tips; spores hyaline, even, subglobose, $3\frac{3}{4}$ – $4\frac{1}{2}\mu$.



Fig. 12.

L. cervinum.

Spores, $\times 870$.

Fructifications 4 cm. high.

On dead wood. Cuba. July.

The type of *C. pallida* is a little more densely branched than that of *C. cervina*, but the specimens are so similar in other respects that they can hardly be regarded as different species. Patouillard published the spores as pale ochraceous, but I find them hyaline as seen with the microscope.

Specimens examined:

Cuba: *C. Wright*, 235, type (in Curtis Herb.); *C. Wright*, 256, type of *Clavaria pallida* (in Curtis Herb.).

7. *L. bicolor* (Peck) Burt, n. comb.

Plate 5, fig. 6.

Clavaria bicolor Peck, N. Y. State Mus. Bul. 54: 954. 1902.
 Not *C. bicolor* Massee, Kew Bul. 1901: 154. 1901.—*C. Peckii*
 Sacc. & D. Sacc. in Sacc. Syll. Fung. 17: 196. 1905.—*C. vestipes*
 Peck, N. Y. State Mus. Bul. 116: 35. 1907.

Type: in N. Y. State Mus. Herb.



Fig. 13.
L. bicolor.
 Spores, $\times 870$.

Fructifications small, 2–2½ cm. high, gregarious; stem slender, 1–2 mm. thick, straight or flexuous, solid, tomentose, pale yellow, divided above into two or more short, orange-colored, compressed branches which are themselves once or twice dichotomously divided; tips acute, concolorous.

Under pine trees. New Hampshire, Massachusetts, and New York. August and September.

The specimens which I have referred to this species are larger in the Massachusetts collection and range from 2½ to 5 cm. high; towards the base the stem is hirsute-tomentose and has dried tawny olive, honey-yellow in the upper portions; the basidia are $45 \times 8 \mu$, with two sterigmata; and the spores are hyaline, even, subglobose, $9\frac{1}{2} \times 8-9 \mu$. Verification by comparison with the type was overlooked.

Specimens examined:

New Hampshire: Chocorua, W. G. Farlow (in Farlow Herb.).

Massachusetts: Coolidge Point, Magnolia, W. G. Farlow.

8. *L. furcellatum* (Fries) Léveillé, as understood by Patouillard, Jour. de Bot. 3: 26. pl. 1. f. 3. 1889; Léveillé, Ann. Sci. Nat. Bot. III. 5: 159. 1846 (*Eriocladus*); Sacc. Syll. Fung. 6: 738. 1888; Not of Berk. & Curtis, Linn. Soc. Bot. Jour. 10: 330. 1868.

Plate 5, fig. 7.

Clavaria furcellata Fries, Linnaea 5: 531. 1830; Epicr. 576. 1838.

Illustrations: Plumier, Filic. Am. pl. 168. f. L. 1705; Patouillard, Jour. de Bot. 3: pl. 1. f. 3. 1889.

Fructifications ascending, somewhat ferruginous, with branches solid, repeatedly dichotomous, distant, rather tough, velvety, acuminate.

Fructifications 7-12 cm. high, pallid ferruginous to ochraceous ferruginous. On rotting wood.

The original description, of which the above is a translation, was based upon collections from Guiana by Roxburgh and Brazil by Beyrich, with reference to the same species of a collection from Bourbon Island by Bory, which differed from the South American specimens by decumbent habit, etc.

At the time of publication of *L. furcellatum*, Fries gave only characters sufficient to distinguish this species from an earlier species, *L. tubulosum*, occurring in the same region and having hollow branches. In the course of time several species of



Fig. 14. *L. furcellatum*. Portion of hymenium showing basidia and a hair, a; spores, s. $\times 870$. From Colombia coll.

South American *Lachnocladium* with solid stems have been recognized, but I have so far failed to find any study upon the original specimens of *Clavaria furcellata* Fries—if these specimens still exist—which gives their microscopical characters and will decide whether *L. furcellatum* as understood by Patouillard or some other *Lachnocladium* with solid branches, is the true *L. furcellatum* (Fries) Lév. The collection from Santa Marta, Colombia, by C. F. Baker, which he distributed under the name *L. brasiliense* upon my determination, I now regard as agreeing more closely with the original description of *L. furcellatum* than

other specimens which I have seen and it has the additional characters published for *L. furcellatum* by Patouillard.

These specimens are tough and certainly coriaceous rather than fleshy, have dried hair-brown below, with final branchlets pinkish buff, everywhere hairy with weak, hyaline hairs $1\ \mu$ in diameter, which protrude beyond the basidia except along the tips of the branchlets; spores becoming pale ochraceous, even, $7-12 \times 4\frac{1}{2}-6\ \mu$, apiculate.

The specimens of *L. furcellatum* of Berk. & Curtis, Fungi Cubenses, are of two species. That collected in Cuba by C. Wright, 831, is *L. brasiliense*; the other by C. Wright, 839, has small hyaline, even spores $3-4 \times 3\ \mu$ but lacks the radiately branched organs characteristic of *L. brasiliense*.

Specimens examined:

Colombia: Bonda, C. F. Baker, 14, distributed under the name *Lachnocladium brasiliense*.

9. *L. erectum* Burt, n. sp.

Plate 5, fig. 8.

Type: in Ell. & Ev., Fungi Col., 808, copy in Burt Herb.

Fructifications of the type arise in a cluster of three from a common point, soon repeatedly dichotomously branched, with branches erect, close together, coriaceous, compressed, drying drab, clothed with a gray down whose hyphae are $50-200\ \mu$ long; fertile tips of the branches cylindric, flexuous, solid, $\frac{1}{2}-1\ \text{cm.}$ long, bearing the hymenium on all sides; spores very pale yellowish under the microscope, even, $6-7 \times 3-3\frac{1}{2}\ \mu$.



Fig. 15.
L. erectum.
Spores, $\times 870$.

Cluster of fructifications 8 cm. high, $2\frac{1}{2}\ \text{cm.}$ in diameter in the branched portion; individual stems 1 cm. high, about 2 mm. in diameter; branches about 1 mm. in diameter.

On rotten frondose wood. West Virginia. September.

L. erectum may be distinguished from the other species of its genus in the eastern United States by occurrence on a woody substratum, by its slender, erect habit of growth and appressed branches, by the soft, downy pubescence of weak hyaline hyphae which stand out at right angles from the stem and branches, and by the small, oblong, apparently slightly colored spores.

Specimens examined:

Exsiccati: Ell. & Ev., Fungi Col., 808, type distribution under the name *Lachnocladium semivestitum*.

West Virginia: Nuttallburg, L. W. Nuttall, in Ell. & Ev., Fungi Col., 808.

10. *L. Atkinsonii* Bresadola in Atkinson, Jour. Myc. 8: 119. 1902; Sacc. Syll. Fung. 17: 198. 1905.

Type: in Cornell Univ. Herb., 4216.

Fructifications somewhat coriaceous; stem elongated, compressed-canaliculate, pallid, tomentose, 5-6 cm. long, 1 cm. thick, somewhat quadrifid at the apex; branches compressed, sulcate, repeatedly verticillate-, or dichotomo-, divided, tomentose on the sterile side, lurid ochraceous; branchlets somewhat terete, furcate at the apex, straw-yellow; spores hyaline or somewhat straw-colored, even, amygdaliform-oblong or somewhat cylindric, $9-10 \times 4\frac{1}{2}-5\frac{1}{2} \mu$; basidia clavate.

Dimensions of the branched portion 6-7 cm. high, 5-6 cm. broad. Blowing Rock, North Carolina. August.

A beautiful species approaching the *Clavariae* but included in *Lachnocladium* on account of having the hymenium unilateral and the stem evidently somewhat waxy.

The above is a translation of the original description of this species of which I have seen no specimens.

11. *L. guadelupense* (Léveillé) Patouillard, Jour. de Bot. 3: 33. pl. 1. f. 7. 1889.

Merisma guadelupense Léveillé, Ann. Sci. Nat. Bot. III. 5: 157. 1846.—*Pterula guadalupensis* (Léveillé) Sacc. Syll. Fung. 6: 742. 1888.

Illustration: Patouillard, loc. cit.

Type: in Museum of Paris Herb., according to Léveillé.

Fructification with very short stem, coriaceous, branched; branches very thin, elongated, fastigiate, compressed, dichotomous, becoming fuscous; terminal branchlets very short, naked, acute; spores brown, warted, apiculate at base, $12 \times 6 \mu$.

Stem hardly 1 cm. long.

Guadeloupe.

The above description is a translation of the original description with addition of the spore characters as given by Patouillard. Perhaps the species could be transferred to *Thelephora* with advantage on account of the dark spores; I have seen no specimens. Bresadola includes this species in *Pterula*, in Ann. Myc. 14: 233. 1916, and gives *Pterula aurantiaca* P. Henn. and *P. squarrosa* P. Henn. as synonyms.

12. *L. odoratum* Atkinson, Ann. Myc. 6: 58. 1908; Sacc. Syll. Fung. 21: 436. 1912.

Type: in Cornell Univ. Herb., 18618.

"Plants 8 cm. high, bases clustered and covered with white mycelium, branches yellowish or grayish, becoming brownish where bruised, branching several times dichotomously, ultimate branches tapering, branched at very tip to make short acute points, branches faintly tinged lemon-yellow, brownish red at very tip, all of larger branches suffused with a reddish tinge, and here and there laterally tomentose, and sterile. Spores transparent, $7-10 \times 3\frac{1}{2}-4\frac{1}{2} \mu$.

"C. U. Herb., No. 18618, growing on very much decayed wood, showing long white cords of mycelium. Connecticut, E. A. White."

The above is the original description. I have seen no authentic specimens but think that they should be compared with *L. Micheneri* and *L. erectum*.

EXCLUDED SPECIES

Pterula setosa Peck, N. Y. State Mus. Rept. 27: 105. 1875, was transferred to *Lachnocladium* by Sacc. Syll. Fung. 6: 740. 1888. Patouillard in Jour. de Bot. 3: 35. 1888, excluded this species from *Lachnocladium*, because its hairiness is due to the elongated sterigmata of the basidia.

(To be continued.)

EXPLANATION OF PLATE

PLATE 5

The figures of this plate have been reproduced natural size from dried herbarium specimens.

Fig. 1. *Lachnocladium brasiliense*. Collected in Cuba by C. Wright, in Curtis Herb.

Fig. 2. *L. cartilagineum*. From the type in Curtis Herb., collected in Cuba by C. Wright, 204.

Fig. 3. *L. Micheneri*. Collected at Newfane, Vermont, by C. D. Howe.

Fig. 4. *L. semivestitum*. From the type in Curtis Herb., collected in Pennsylvania by E. Michener, 1184.

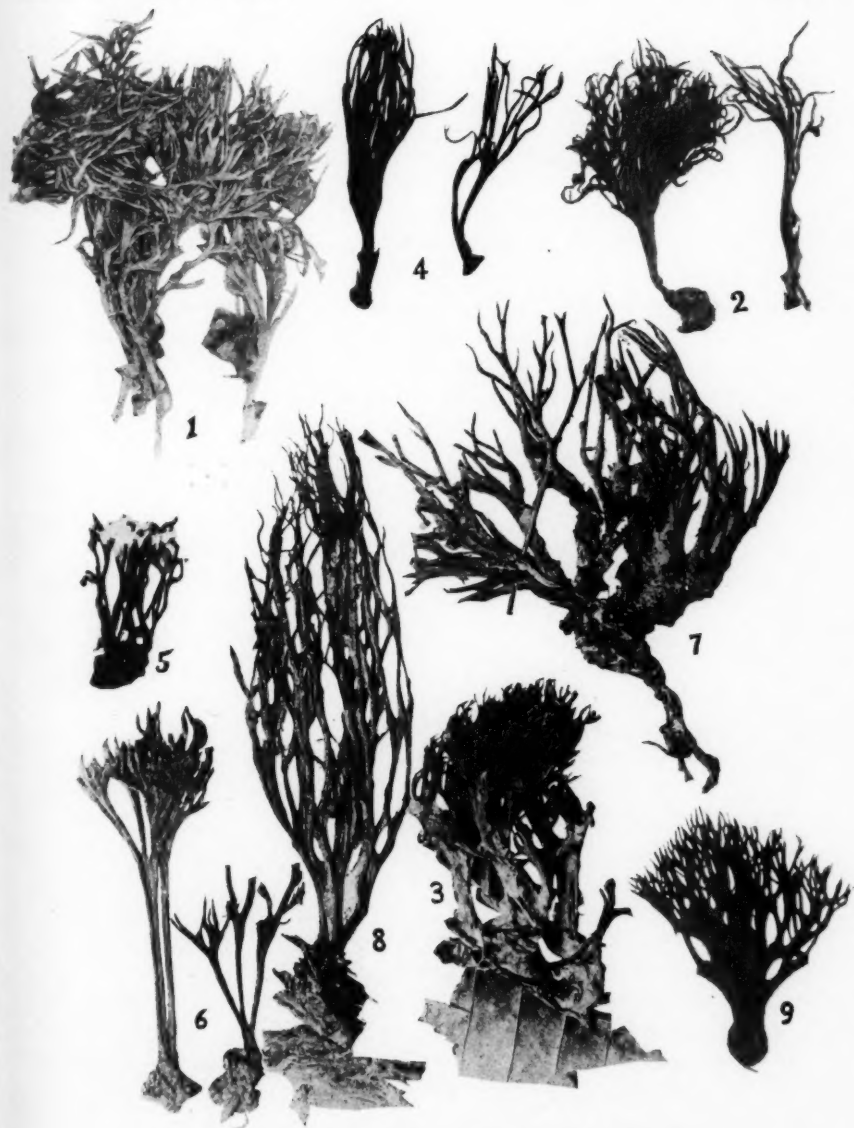
Fig. 5. *L. sub simile*. From the type in Curtis Herb., collected in New Jersey by Laning, 49.

Fig. 6. *L. bicolor*. Collected at Magnolia, Massachusetts, by W. G. Farlow.

Fig. 7. *L. furcellatum*. Collected at Bonda, Colombia, by C. F. Baker, 14.

Fig. 8. *L. erectum*. From the type in Burt Herb., collected at Nuttallburg, West Virginia, by L. W. Nuttall.

Fig. 9. *L. cervinum*. From the type of *Clavaria pallida* in Curtis Herb., collected in Cuba by C. Wright, 256.



BURT—THELEPORACEAE OF NORTH AMERICA

1. *LACHNOCLADIUM BRASILIENSE*.—2. *L. CARTILAGINEUM*.—3. *L. MICHENERI*.—
4. *L. SEMIVESTITUM*.—5. *L. SUBSIMILE*.—6. *L. BICOLOR*.—7. *L. FURCELLATUM*.—
8. *L. ERECTUM*.—9. *L. CERVINUM*.

A SUBTERRANEAN ALGAL FLORA

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That there exists a subterranean algal flora, independent of the terrestrial flora, is a possibility which has seemed so remote that little, if any, attempt has been made to investigate this subject. Many of the earlier writers upon the algae, including Ehrenberg (*Mikrogeologie*), referred to the algae of the soil, and Gregory,¹ in 1856, discussed somewhat in detail the diatoms obtained from the soil adhering to the roots of dried plants in herbaria.

Robbins,² in an account of the algae in some Colorado soils, lists about a dozen blue-greens, one diatom, and two unicellular grass-greens obtained from cultures inoculated with soil. In this case, however, as in all previous accounts, there is no indication that the various forms were not immediately derived from the surface or within a very short distance of the surface of the soil. Robbins removed any loose debris on the surface but the sample consisted of not more than the first three or four inches of earth and included any forms which might have originated terrestrially. These samples, after being thoroughly mixed, were shaken up with distilled water and an amount corresponding to 10 gms. of soil drawn off and distributed over the surface of sterile quartz sand in flasks. Adequate precautions against contamination were observed throughout.

More recently Miss Bristol³ has reported upon the vitality of algae from old stored soils, but from her account it is obvious

¹ Gregory, W. On the presence of Diatomaceae, Phylolitharia, and sponge spicules in soils which support vegetation. *Am. Jour. Sci. and Arts* II. 21: 434-437. 1856.

² Robbins, W. W. Algae in some Colorado soils. *Colo. Agr. Exp. Sta., Bull.* 184: 24-36. pl. 1-4. 1912.

³ Bristol, B. M. On the retention of vitality by algae from old stored soils. *New Phytol.* 18: 92. 1919.

that only samples from the surface were used, and with a single exception any reference in the literature to soil algae may be regarded as having only to do with those forms which grow at or near the surface. Esmarch,¹ however, in a rather extensive paper, attempted to indicate not only the distribution of *Cyanophyceae* upon the surface of various soils but also their occurrence underground. His method was to use Petri dishes about 2 cm. deep, into which 1 cm. of the soil to be studied was introduced. The soil was moistened with sterile water and a piece of filter-paper placed over the surface. The cultures were kept in the greenhouse with diffuse light at a temperature of from 20 to 25° C., and after periods of from two days to two months growth appeared through the filter-paper.

In investigating the distribution of blue-green algae on surface soils an attempt was made to determine whether cultivation influenced their distribution. Accordingly, 4 types of uncultivated soils, including sandy meadow, marshy bog, forest humus, and moist sand, were investigated. On the sandy meadow, which contained traces of humus, but 3 out of 34 samples collected showed the presence of *Cyanophyceae* on the surface. On the marshy bog soil, after a period of three months, none of the 35 cultures showed any blue-green algae, although a few diatoms and grass-green algae were present. Both the forest humus and the moist sand gave good results, so far as indicating the presence of numerous blue-greens on the surface. In cultivated soils, 3 types were used, namely, sandy, clay, and marshy. Of these, 29 out of 45 samples of sandy soil contained *Cyanophyceae*, comprising some 12 different kinds. On the clay soil, 35 out of 37 samples produced blue-green algae with 23 species. On the marshy soil, of the 40 cultures all but 2 showed growth, 22 species being found. While, in general, the above increase indicates that a greater number of blue-greens were found on cultivated than uncultivated soils, the number of samples was so few and taken from such a limited area that no very exact conclusions could be drawn. Any difference in

¹ Esmarch, F. Untersuchungen über die Verbreitung der Cyanophyceen auf und in verschiedenen Böden. *Hedwigia* 55: 224-273. 1914.

the two types of soil seemed to be determined by the moisture content and the mineral nutrient content.

Coming to the question of the presence of algae underground, Esmarch continued to attempt to correlate their growth with different types of soil. Samples were taken at about the same place as those used for surface cultures, at a depth usually of from 10 to 25 cm. A few, however, extended from 30 to 50 cm. below the surface. All samples were obtained in a manner to prevent surface contamination. The results are grouped according to the kind of soil. In tilled land 13 cultures were made from sandy soil, 12 from clay, and 20 from marshy soil. Only 5 of these contained no blue-green algae and were from places where there were no surface forms. In all, 18 separate species were found and the number decreased as we went deeper into the soil. In the meadow land 23 out of 32 cultures contained blue-greens, with 15 species represented, all these occurring on the surface as well as underground. In moist sand practically all cultures gave results, with 20 different species showing growth. The brown heath and bog soils produced no blue-greens from below the surface.

Esmarch records the occurrence of these subterranean forms as due to the distribution of surface organisms by seepage of surface waters or by being carried down by earth worms and other soil organisms, and, although he was inclined to believe that the blue-greens found by him beneath the surface could grow in the absence of light, he does not regard the work of other investigators on this subject as being altogether conclusive. Furthermore, Esmarch doubts that the blue-green filaments found at considerable depths in the soil have been able to persist there for any length of time. In order to demonstrate this, he prepared cultures in Petri dishes containing 7-8 mm. of soil, on which a piece of filter-paper was placed with certain blue-greens on the surface. The filter-paper was then covered with about 1 cm. of soil, the cultures moistened with distilled water and covered with black paper, the whole being placed in a light-proof case. The temperature was maintained at from 15 to 20° C. After a longer or shorter time, depending upon the

character and mineral content of the soil as well as upon individual differences of the algae themselves, the filaments became discolored, passing from a pale blue-green through a yellowish green to yellow. At first the contents of the cells appeared normal and were apparently in a healthy condition. Later the filaments disintegrated, leaving only spores and heterocysts behind. Cultures which showed practically no normal filaments were removed from the light-proof case, the moistened filter-paper placed on top of the soil, and after about 12 weeks' exposure to daylight again showed blue-green growth. Esmarch regarded this experiment as definitely indicating the impossibility of blue-greens persisting beneath the surface for any length of time, and considered that while the absence of light was a factor, the destructive influence of the soil itself must be taken into consideration.

Aside from this paper of Esmarch's, there appears to be no record of algae growing at considerable depths in the soil, and the investigation here recorded—a preliminary announcement of which was made at the Pittsburgh meeting of the Botanical Society of America, on December 29, 1917—is believed to be the first definite indication that there may exist in the soil, at depths up to 1 m., at least one grass-green alga which is practically always present as a subterranean organism under conditions which preclude its having recently been derived from the surface and accidentally carried down to various depths.

METHODS

The method employed throughout this study was essentially the following:

About $1\frac{1}{2}$ inches of sand was placed in pint milk bottles, to which was added 150 cc. of a culture solution. The bottles were plugged with cotton and sterilized at 8-10 pounds pressure for $\frac{1}{2}$ hour. The culture solution was prepared $\frac{1}{2}$ the strength of the formula of a modified Beyerinck's solution used by Moore,¹ because of the soluble material present in the sand.

¹ Moore, G. T. Methods for growing pure cultures of algae. *Jour. Appl. Microsc.* 6: 2309-2314. 1903.

The formula undiluted was:

Ammonium nitrate.....	.5 gm.
Monobasic potassium phosphate.....	.2 gm.
Magnesium sulphate.....	.2 gm.
Calcium chloride.....	.1 gm.
Iron sulphate.....	Trace
Water.....	1000 cc.

The bottles were inoculated in duplicate under sterile conditions with about 10 gms. of soil taken from various depths. Every precaution was taken so that the exposed surface was not contaminated with small particles of soil carried down from the upper layers. The spatula by which the samples were taken was sterilized after each inoculation. Checks were run with bottles that were exposed to the air where the inoculations were taken. In order to lessen the amount of evaporation waxed paper covers were placed over the cotton plugs. The sand was slanted in the bottle so that part of it was not submerged, in this way giving various moisture conditions in the culture. The cultures were then placed in cases where they received good light for at least part of the day. The water lost by evaporation was restored from time to time with sterile water.

In order to compare the algal flora of different regions and soil conditions, 10 different series of bottles were inoculated with soil samples from various parts of the Missouri Botanical Garden, 1 from Woods Hole, Massachusetts, and 3 from the vicinity of Santa Ana, California. The varieties of soil examined were heavy clay, loose clay, sand, sandy alkali, sandy gravel and humus. All subterranean cultures were obtained from places where the soil had not been disturbed for at least a number of years. This precaution was necessary in order that the algal growths obtained would represent those typical of subterranean conditions and not merely recent surface infections. At no time did a single check culture show growth, thus eliminating the possibility of algal infection from the air.

SERIES B

INOCULATED OCTOBER 1, 1915. SAMPLE FROM MISSOURI BOTANICAL GARDEN, NORTHWEST CORNER OF LINNEAN HOUSE WALL. FILLED IN TO 45 CM.; BLACK HUMUS TO 20 CM.; BELOW THIS A GRADUAL CHANGE TO PURE CLAY; VERY FINE CLAY AT 37 CM.; DEPTH LIMIT 100 CM.

Ser. B	Depth	Feb. 24, 1916	Mar. 29, 1916	Apr. 11, 1916	June 7, 1916	Aug. 25, 1916	Nov. 14, 1916
B'	Surface			<i>Protoderma viride</i>	<i>P. viride</i> (motile) <i>Stichococcus bacillaris</i>	<i>P. viride</i> (motile) <i>S. bacillaris</i>	<i>P. viride</i> (motile) <i>S. bacillaris</i>
B'	Surface		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> (motile)	<i>P. viride</i> (motile) <i>S. bacillaris</i> <i>Ulothrix variabilis</i>	<i>P. viride</i> Diatoms
B''	Surface				<i>P. viride</i>	<i>P. viride</i> (motile) <i>S. bacillaris</i> <i>U. variabilis</i>	<i>P. viride</i>
1	10 cm.		<i>P. viride</i> (motile)	<i>P. viride</i> <i>Cladophora</i> sp. Diatoms	<i>P. viride</i> <i>Cladophora</i> sp. Diatoms	<i>P. viride</i> <i>Trochiscia?</i> <i>U. variabilis</i> Diatoms	<i>P. viride</i> <i>U. variabilis</i> Diatoms
1'	10 cm.			<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> Diatoms
2	20 cm.		<i>P. viride</i> (motile) Diatoms	<i>P. viride</i> (motile) Diatoms	<i>P. viride</i> (motile) Diatoms	<i>P. viride</i> (motile) Diatoms	<i>P. viride</i> (motile) Diatoms
2'	20 cm.						<i>P. viride</i> (motile) Diatoms

SERIES B—Continued

Ser. B	Depth	Feb. 24, 1916	Mar. 29, 1916	Apr. 11, 1916	June 7, 1916	Aug. 25, 1916	Nov. 14, 1916
3	30 cm.			<i>P. viride</i>	<i>P. viride</i> (motile)	<i>P. viride</i>	<i>P. viride</i> <i>S. bacillaris</i>
3'	30 cm.						<i>P. viride</i> <i>S. bacillaris</i>
4	40 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> (motile)	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> (motile) Diatoms
4'	40 cm.						
5	50 cm.		<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i>
5'	50 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms
6	60 cm.						Diatoms
6'	60 cm.						Diatoms
7	70 cm.						
7'	70 cm.					<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms
7''	70 cm.						<i>S. bacillaris</i> Diatoms

8 (80 cm.), 9 (90 cm.), and 10 (100 cm.), no growth.

SERIES C

INOCULATED OCTOBER 1, 1916. SAMPLE FROM MISSOURI BOTANICAL GARDEN, HOLE IN CENTER OF LINNEAN HOUSE. SURFACE STONY AND MOIST; FILLED IN TO 20 CM. WITH CLAY, LIME AND BRICK; 20-40 CM., A MIXTURE OF CLAY AND HUMUS; 40-100 CM., GRADUAL CHANGE FROM CLAY TO VERY FINE CLAY. CULTURES C3 AND C3' WERE TAKEN IN A TAR-LIKE STRATA; DEPTH LIMIT 100 CM.

Ser. C	Depth	Jan. 14, '16	Mar. 25, '16	Aug. 22, '16	Nov. 10, '18
C	Surface		<i>Ulothriza variabilis</i> <i>Stichococcus bacillaris</i>	<i>Protoderma viride</i> <i>S. bacillaris</i> <i>U. variabilis</i> <i>Trochiscia?</i>	<i>P. viride</i> <i>S. bacillaris</i> <i>Trochiscia?</i> <i>U. variabilis</i> (plasmolyzed)
C'	Surface	<i>P. viride</i> <i>U. variabilis</i> <i>S. bacillaris</i>	<i>P. viride</i> <i>U. variabilis</i> <i>S. bacillaris</i>	<i>P. viride</i> <i>S. bacillaris</i> <i>U. variabilis</i> <i>Trochiscia?</i>	<i>P. viride</i>
C''	Surface		<i>P. viride</i>	<i>P. viride</i> <i>S. bacillaris</i> <i>U. variabilis</i> <i>Trochiscia?</i>	<i>P. viride</i> <i>U. variabilis</i>
1	10 cm.			<i>P. viride</i>	<i>P. viride</i>
1'	10 cm.			<i>P. viride</i>	<i>P. viride</i>
2	20 cm.			<i>P. viride</i>	<i>P. viride</i>
2'	20 cm.			<i>P. viride</i>	<i>P. viride</i>
3	30 cm.			<i>P. viride</i>	<i>P. viride</i>
3'	30 cm.				<i>P. viride</i> <i>U. variabilis</i>
4	40 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
4'	40 cm.				<i>P. viride</i>
5	50 cm.			<i>P. viride</i>	<i>P. viride</i>
5'	50 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> <i>S. bacillaris</i>
6	60 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>

SERIES C—*Continued*

Ser. C	Depth	Jan. 14, '16	Mar. 25, '16	Aug. 22, '16	Nov. 10, '18
6'	60 cm.			<i>P. viride</i>	<i>P. viride</i>
7	70 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
7'	70 cm.				<i>P. viride</i>
8	80 cm.				<i>P. viride</i> Diatoms
8'	80 cm.				<i>P. viride</i> (scant growth)
9	90 cm.		<i>P. viride</i>	<i>P. viride</i> (motile)	<i>P. viride</i>
9'	90 cm.				
10	100 cm.				
10'	100 cm.			<i>P. viride</i>	<i>P. viride</i> (motile)

SERIES D

INOCULATED MAY 10, 1916. SAMPLE FROM MISSOURI BOTANICAL GARDEN, CUT IN NEW EMBANKMENT ALONG ROADSIDE EAST OF NEW PROPAGATING HOUSES. NATURAL FORMATION; BLACK HUMUS TO 20 CM.; CLAY TO VERY FINE CLAY THE REMAINING DEPTH; DEPTH LIMIT 120 CM.

Ser. D	Depth	June 10, 1916	June 17, 1916	Aug. 24, 1916	Mar. 8, 1917	Nov. 22, 1918
D	Surface	<i>Protoderma viride</i>	<i>P. viride</i> <i>Cladophora</i> sp. <i>Ulothrix variabilis</i>	<i>P. viride</i> <i>Cladophora</i> sp. <i>U. variabilis</i> Diatoms	<i>P. viride</i> <i>U. variabilis</i> <i>Stichococcus bacillaris</i> Diatoms	<i>P. viride</i> <i>Cladophora</i> sp. <i>U. variabilis</i> <i>S. bacillaris</i> Diatoms
D	Surface			<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
1	10 cm.		<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i>
1'	10 cm.		<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i>	<i>P. viride</i> (plasmolyzed)
2	20 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>	
2'	20 cm.		<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
3	30 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i>	<i>P. viride</i>
3'	30 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i>	
4	40 cm.		<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>	
4'	40 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> Diatoms	

SERIES D—Continued

Ser. D	Depth	June 10, 1916	June 17, 1916	Aug. 24, 1916	Mar. 8, 1917	Nov. 22, 1918
5	50 cm.			<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> Diatoms
5'	50 cm.		<i>P. viride</i>	<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms	
6	60 cm.					
6'	60 cm.			<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
7	70 cm.					
7'	70 cm.			<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
8	80 cm.					
8'	80 cm.			<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms
9	90 cm.			<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms

100 (100 cm.), 110 (110 cm.), and 120 (120 cm.), no growth.

SERIES E

INOCULATED JUNE 6, 1916. SAMPLE FROM MISSOURI BOTANICAL GARDEN, HOLE IN NORTH AMERICAN TRACT. NATURAL FORMATION; BLACK HUMUS TO 20-30 CM.; BELOW THIS CLAY TO VERY FINE CLAY; DEPTH LIMIT 80 CM.

Ser. E	Depth	Sept. 15, '16	Dec. 16, '16	Mar. 29, '17	Nov. 16, '18
E	Surface		<i>Protoderma viride</i>	<i>P. viride</i> <i>Ulothrix variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>
E'	Surface			<i>P. viride</i> <i>U. variabilis</i>	Diatoms
E''	Surface			<i>P. viride</i> <i>U. variabilis</i> <i>Cladophora</i> sp.	<i>P. viride</i>
1	10 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
1'	10 cm.			<i>P. viride</i>	<i>P. viride</i>
2	20 cm.		<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i>
2'	20 cm.			<i>P. viride</i> <i>U. variabilis</i>	
3	30 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
3'	30 cm.			<i>P. viride</i>	<i>P. viride</i>
4	40 cm.			<i>P. viride</i>	<i>P. viride</i>
4'	40 cm.			<i>P. viride</i>	<i>P. viride</i>
5	50 cm.			<i>P. viride</i>	<i>P. viride</i>
5'	50 cm.				
6	60 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
6'	60 cm.				
7	70 cm.			<i>P. viride</i>	<i>P. viride</i>
7'	70 cm.				<i>P. viride</i>
8	80 cm.				

SERIES F

INOCULATED JUNE 6, 1916. SAMPLE FROM MISSOURI BOTANICAL GARDEN, HOLE, AT EDGE OF WOODED NORTH AMERICAN TRACT, DUG UNDER TREES. NATURAL FORMATION; BLACK HUMUS TO 20-30 CM.; REMAINING DEPTH CLAY TO VERY FINE CLAY; DEPTH LIMIT 70 CM.

Ser. F	Depth	Aug. 25, 1916	Sept. 15, 1916	Sept. 19, 1916	Mar. 30, 1917	Nov. 19, 1916
F	Surface		<i>Protoderma viride</i>	<i>P. viride</i> <i>Ulothrix variabilis</i>	<i>P. viride</i>	<i>P. viride</i>
F'	Surface		<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i> <i>Stichococcus bacillaris</i>	<i>P. viride</i> (motile)	<i>P. viride</i>
F''	Surface		<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> (motile)	<i>P. viride</i> (motile)
1	10 cm.		<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i>
1'	10 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
2	20 cm.		<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>
2'	20 cm.		<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i>
3	30 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
3'	30 cm.		<i>P. viride</i> <i>Trochiscia?</i>	<i>P. viride</i> Diatoms	<i>P. viride</i>	<i>P. viride</i>
4	40 cm.		<i>P. viride</i>	<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms	<i>P. viride</i> Diatoms
4'	40 cm.			<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
5	50 cm.		<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>
5'	50 cm.			<i>P. viride</i>		<i>P. viride</i> <i>U. variabilis</i>

SERIES F—Continued

Ser. F	Depth	Aug. 25, 1916	Sept. 15, 1916	Sept. 19, 1916	Mar. 30, 1917	Nov. 19, 1916
6	60 cm.		<i>P. viride</i> <i>Trochiscia?</i>	<i>P. viride</i> <i>U. variabilis</i>		<i>P. viride</i> <i>U. variabilis</i>
6'	60 cm.			<i>P. viride</i> <i>U. variabilis</i>		<i>P. viride</i>
7	70 cm.		<i>P. viride</i>	<i>P. viride</i>		
7'	70 cm.					

SERIES G

INOCULATED SEPTEMBER 26, 1916. SAMPLE TAKEN FROM MISSOURI BOTANICAL GARDEN, NEWLY EXCAVATED TRENCH PARALLEL WITH LINNEAN HOUSE WALL. PACKED ROAD-BED INTERMIXED WITH TAR TO 10 CM.; NATURAL FORMATION AT 20 CM.; REMAINING DEPTH GRADUALLY GRADING INTO CLAY; DEPTH LIMIT 40 CM.

Ser. G	Depth	Nov. 2, '16	Mar. 12, '17
G	Surface	<i>Protoderma viride</i> <i>Stichococcus bacillaris</i> <i>Ulothrix variabilis</i>	<i>P. viride</i> <i>S. bacillaris</i> <i>U. variabilis</i>
G'	Surface	<i>P. viride</i> <i>Cladophora</i> sp. <i>S. bacillaris</i> <i>U. variabilis</i>	<i>P. viride</i> <i>Cladophora</i> sp. <i>S. bacillaris</i> <i>U. variabilis</i>
1	10 cm.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.
1'	10 cm.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.
2	20 cm.	<i>P. viride</i>	<i>P. viride</i>
2'	20 cm.	<i>P. viride</i>	<i>P. viride</i>
3	30 cm.	<i>P. viride</i>	<i>P. viride</i>
3'	30 cm.	<i>P. viride</i>	<i>P. viride</i>
4	40 cm.	<i>P. viride</i>	<i>P. viride</i>
4'	40 cm.	<i>P. viride</i>	<i>P. viride</i>

SERIES H

INOCULATED OCTOBER 12, 1918. SAMPLE FROM MISSOURI BOTANICAL GARDEN, NEWLY EXCAVATED AREA IN NORTH END NEAR SERVICE SHOPS. CLAY AND HUMUS TO 25 CM.; REMAINING DEPTH CLAY; DEPTH LIMIT 100 CM.

Ser. H	Depth	Nov. 20, '18	Jan. 21, '19	Mar. 21, '19	July 10, '19
H	Surface		<i>Protoderma viride</i> <i>Ulothrix variabilis</i>	<i>P. viride</i> <i>Nostoc muscorum</i> <i>Oscillatoria formosa</i> <i>O. anoema</i> <i>O. splendida</i> <i>Scytonema Hofmanni</i> <i>Navicula atemoides</i> <i>Nitzschia Kützingeriana</i> <i>Hantzschia amphioxys</i>	<i>P. viride</i> <i>N. muscorum</i> <i>O. formosa</i> <i>O. anoema</i> <i>O. splendida</i> <i>S. Hofmanni</i> <i>N. atemoides</i> <i>N. Kützingeriana</i> <i>H. amphioxys</i> <i>Stichococcus bacillaris</i>
H'	Surface				
1	5 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. muscorum</i> <i>O. chlorina</i> <i>N. atemoides</i> <i>N. Kützingeriana</i>	<i>P. viride</i> <i>N. muscorum</i> <i>O. chlorina</i> <i>N. atemoides</i> <i>N. Kützingeriana</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>N. muscorum</i> <i>O. chlorina</i> <i>N. atemoides</i> <i>N. Kützingeriana</i> <i>Cladophora</i> sp.
1'	5 cm.		<i>P. viride</i> <i>N. muscorum</i> <i>S. Hofmanni</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i>	<i>P. viride</i> <i>N. muscorum</i> <i>S. Hofmanni</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i>	<i>P. viride</i> <i>N. muscorum</i> <i>S. Hofmanni</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i>
2	10 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. muscorum</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i>	<i>P. viride</i> <i>N. muscorum</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i>	<i>P. viride</i> <i>N. muscorum</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i>
2'	10 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. muscorum</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>N. muscorum</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>N. muscorum</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingeriana</i> <i>Cladophora</i> sp.

SERIES H—Continued

Ser. H	Depth	Nov. 20, '18	Jan. 21, '19	Mar. 21, '19	July 10, '19
3	15 cm.	<i>P. viride</i>	<i>P. viride</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingiana</i> <i>Hantzschia</i> <i>amphioxys</i>	<i>P. viride</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingiana</i> <i>H. amphioxys</i>	<i>P. viride</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>N. Kützingiana</i> <i>H. amphioxys</i>
3'	15 cm.	<i>P. viride</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>S. Hofmanni</i> <i>N. atemoides</i> <i>N. Kützingiana</i> <i>H. amphioxys</i>	<i>P. viride</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>S. Hofmanni</i> <i>N. atemoides</i> <i>N. Kützingiana</i> <i>H. amphioxys</i>	<i>P. viride</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>S. Hofmanni</i> <i>N. Kützingiana</i> <i>H. amphioxys</i>	<i>P. viride</i> <i>O. amphibia</i> <i>O. subtilissima</i> <i>N. atemoides</i> <i>S. Hofmanni</i> <i>N. Kützingiana</i> <i>H. amphioxys</i>
4	20 cm.	<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i>	<i>P. viride</i> <i>U. variabilis</i> <i>O. amphibia</i> <i>O. chlorina</i> <i>O. subtilissima</i>	<i>P. viride</i> <i>U. variabilis</i> <i>O. amphibia</i> <i>O. chlorina</i> <i>O. subtilissima</i>
4'	20 cm.	<i>P. viride</i>	<i>P. viride</i> <i>U. variabilis</i> <i>O. amphibia</i> <i>O. chlorina</i> <i>O. subtilissima</i> <i>N. muscorum</i> <i>S. Hofmanni</i> <i>N. atemoides</i> <i>N. Kützingiana</i>	<i>P. viride</i> <i>U. variabilis</i> <i>O. amphibia</i> <i>O. chlorina</i> <i>O. subtilissima</i> <i>N. muscorum</i> <i>S. Hofmanni</i> <i>N. atemoides</i> <i>N. Kützingiana</i>	<i>P. viride</i> <i>U. variabilis</i> <i>O. amphibia</i> <i>O. chlorina</i> <i>O. subtilissima</i> <i>N. muscorum</i> <i>S. Hofmanni</i> <i>N. atemoides</i> <i>N. Kützingiana</i>
5	25 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
5'	25 cm.				
6	30 cm.		<i>P. viride</i> <i>U. variabilis</i> <i>Cladophora</i> sp. <i>N. atemoides</i>	<i>P. viride</i> <i>U. variabilis</i> <i>Cladophora</i> sp. <i>N. atemoides</i>	<i>P. viride</i> <i>U. variabilis</i> <i>Cladophora</i> sp. <i>N. atemoides</i>
6'	30 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>N. atemoides</i>
7	35 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>U. variabilis</i> <i>N. atemoides</i>	<i>P. viride</i> <i>U. variabilis</i> <i>N. atemoides</i>
7'	35 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>N. atemoides</i>

SERIES H—Continued

Ser. H	Depth	Nov. 20, '18	Jan. 21, '19	Mar. 21, '19	July 10, '19
8	40 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
8'	40 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
9	45 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
9'	45 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.
10	50 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
10'	50 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Trochiscia</i> ?	<i>P. viride</i>	<i>P. viride</i>
11	55 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Trochiscia</i> ?	<i>P. viride</i>	<i>P. viride</i>
11'	55 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
12	60 cm.		<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.	<i>P. viride</i> <i>Cladophora</i> sp.
12'	60 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
13	65 cm.	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
13'	65 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
14	70 cm.				
14'	70 cm.				
15	80 cm.				
15'	80 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
16	90 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
16'	90 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
17	100 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>
17'	100 cm.		<i>P. viride</i>	<i>P. viride</i>	<i>P. viride</i>

SERIES J

INOCULATED JUNE 27, 1919. SAMPLE FROM MISSOURI BOTANICAL GARDEN,
ABOUT 10 CM. FROM THE PLACE IN SERIES H; DEPTH LIMIT 100 CM.

Ser. J	Depth	Sept. 23, '19	Nov. 4, '19
J	Surface	<i>Protoderma viride</i> <i>Nostoc muscorum</i> <i>Hantzschia amphioxys</i>	<i>P. viride</i> <i>N. muscorum</i> <i>H. amphioxys</i>
J'	Surface	<i>P. viride</i>	<i>P. viride</i>
1	5 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Cladophora</i> sp. <i>H. amphioxys</i>
1'	5 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Cladophora</i> sp. <i>H. amphioxys</i>
2	10 cm.	<i>P. viride</i> <i>Ulothrix variabilis</i>	<i>P. viride</i> <i>U. variabilis</i> <i>Cladophora</i> sp.
2'	10 cm.	<i>P. viride</i> (motile)	<i>P. viride</i> <i>Navicula atemoides</i>
3	15 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. atemoides</i>
3'	15 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. atemoides</i>
4	20 cm.		
4'	20 cm.		
5	25 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. atemoides</i>
5'	25 cm.	<i>P. viride</i>	<i>P. viride</i>
6	30 cm.	<i>P. viride</i> (motile)	<i>P. viride</i>
6'	30 cm.	<i>P. viride</i>	<i>P. viride</i>
7	35 cm.		<i>P. viride</i>

SERIES J—Continued

Ser. J	Depth	Sept. 23, '19	Nov. 4, '19
7'	35 cm.	<i>P. viride</i>	<i>P. viride</i>
8	40 cm.	<i>P. viride</i>	<i>P. viride</i>
8'	40 cm.	<i>P. viride</i>	<i>P. viride</i>
9	45 cm.		
9'	45 cm.		
10	50 cm.	<i>P. viride</i>	<i>P. viride</i>
10'	50 cm.	<i>P. viride</i>	<i>P. viride</i>
11	55 cm.	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>N. atemoides</i>
11'	55 cm.	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>N. atemoides</i>
12	60 cm.	<i>P. viride</i>	<i>P. viride</i> <i>Oscillatoria amphibia</i>
12'	60 cm.	<i>P. viride</i>	<i>P. viride</i>
13	65 cm.	<i>P. viride</i>	<i>P. viride</i>
13'	65 cm.	<i>P. viride</i> (motile)	<i>P. viride</i> <i>Trochiscia?</i>
14	70 cm.	<i>P. viride</i> <i>H. amphioxys</i> <i>N. atemoides</i>	<i>P. viride</i> <i>H. amphioxys</i> <i>N. atemoides</i> <i>O. amphibia</i>
14'	70 cm.	<i>P. viride</i> <i>H. amphioxys</i> <i>N. atemoides</i>	<i>P. viride</i> <i>H. amphioxys</i> <i>N. atemoides</i>
15	75 cm.		<i>P. viride</i>
15'	75 cm.		

SERIES J—Continued

Ser. J	Depth	Sept. 23, '19	Nov. 4, '19
16	80 cm.	<i>P. viride</i> (motile) <i>Trochiscia</i> ?	<i>P. viride</i> (motile) <i>Trochiscia</i> ?
16'	80 cm.	<i>P. viride</i>	<i>P. viride</i> (motile)
17	85 cm.	<i>P. viride</i>	<i>P. viride</i>
17'	85 cm.	<i>P. viride</i> <i>N. atemoides</i>	<i>P. viride</i> <i>N. atemoides</i>
18	90 cm.	<i>P. viride</i>	<i>P. viride</i>
18'	90 cm.	<i>P. viride</i>	<i>P. viride</i> <i>H. amphiozys</i> <i>N. atemoides</i>
19	95 cm.	<i>P. viride</i> (motile)	<i>P. viride</i> <i>N. atemoides</i>
19'	95 cm.	<i>P. viride</i>	<i>P. viride</i> <i>N. atemoides</i>
20	100 cm.		<i>P. viride</i> <i>H. amphiozys</i> <i>N. atemoides</i>
20'	100 cm.		<i>P. viride</i> <i>H. amphiozys</i> <i>N. atemoides</i>

Series A, inoculated with very poor soil from the Missouri Botanical Garden, was a preliminary series and not carefully examined, so that no record is tabulated. Cultures were taken at the surface and at 20, 40, and 60 cm. below the surface. *Protoderma viride* was found in all the cultures and *Anabaena* appeared in those taken at a depth of 20 cm.

Series H contained a greater number of blue-green forms than any of the other series, and it seemed desirable to repeat the experiment. Series I was inoculated March 6, and Series J, June 27, 1919, with soil taken within a few centimeters of the area used in Series H. The surface of the embankment was scraped off to expose a clean area. At the end of 3 months in Series I, and 40 days in Series J, no growth was apparent, whereas in Series H growth had been abundant in almost all of the bottles in the latter period of time.

Since Series I showed no growth at the end of 90 days, the cultures were discarded. Growth in Series J first appeared at the end of about 40 days. Even at the end of 3 months these cultures showed less growth and fewer species of algae than those of Series H. However, *Protoderma viride* again appeared throughout. The fact that there was no growth in Series I and that fewer species of algae appeared in Series J may have been due to the surface of the embankment having been exposed during the winter months and the low temperature probably having killed some of the forms originally present in Series H. This exposure probably killed many or all of the vegetative cells of the algae which survived, and thus the delayed growth in Series J might be explained by the persistence of spores which required a longer period of time in which to produce a visible growth.

The cultures of soil from Woods Hole, Mass. and Santa Ana, Calif. were taken in exactly the same manner to a depth of 1 meter as the preceding ones. The soil at Woods Hole was sandy gravel containing several large boulders. The series taken at Santa Ana were especially valuable because of the different soil conditions, one series being taken from very sandy soil and another from sandy alkali soil. The third series was taken

from ordinary garden soil. No tabulated results were kept of these because *Protoderma* appeared in all of the cultures.

From the above tables, it will be seen that there exists a subterranean algal flora independent of the nature of the soil and the locality. A wide variety of algae does not appear in the soils examined but in most cases the variety is as great as at the surface. The absence of a variety of blue-green algae and the constant occurrence of *Protoderma viride* is especially noticeable. The fact that the latter occurs at the greatest depth and in every soil seems to indicate that it is especially adapted to live under subterranean conditions.

The greater number of soil samples studied in this investigation is comparable to those termed uncultivated forest soils by Esmarch. The results in general are also similar in that he found no *Cyanophyceae* on the surface or underground. The soils in all cases were uncultivated, a fact which may account for fewer cultures showing blue-green forms than reported by Robbins and Esmarch. It is possible that the unicellular green alga reported by Robbins is a form of *Protoderma viride*.

As has been pointed out by Esmarch, this flora undoubtedly originated from the surface flora, but its persistence in the soil at such great depths is noteworthy. It is inconceivable that in undisturbed soil compact as clay, algae could be carried down very far by surface waters. There were no evidences of worm-holes or penetration by surface organisms in these soils. This would seem to indicate that the algae are in a vegetative condition and actually grow in the soil.

The amount of growth in the various bottles can be taken to represent in a general way the abundance of the algae in the soil at the different depths, since the cultures were all kept under similar conditions. It was impossible to determine this from a microscopical examination of the soil samples, because the algae were present in such small quantities that they could not be easily found among the soil particles. The greatest growth was never at the surface but at a depth of 5-60 cm. This was due probably to the dry conditions existing at the surface. From 60 to 100 cm. the amount of algae in the cultures gradu-

ally became less. In some cases this was due to the disappearance of some of the algal forms but usually the amount of an individual form also decreased. *Protoderma* was always more abundant towards the surface than at the greater depths.

The time in which the growth was first perceptible in the cultures varied from about 3 weeks to 3 months. This was dependent no doubt upon the amount of algae and also upon the amount in a vegetative condition in the soil. Obviously, vegetative cells would produce a growth in less time than spores.

The resistance of these algae to desiccation was demonstrated in series B-F inclusive, in which the cultures were allowed to evaporate for a period of about 18 months, from March, 1917, to November, 1918. The cultures became quite dry within several months, so that the algae were exposed to desiccating conditions for about 12 months. In the fall of 1918, the cultures were reexamined and in most cases the algae seemed in a healthy condition. After the cultures were moistened vigorous growth occurred again. Especially noticeable was the fact that while many of the vegetative cells of *Ulothrix* and *Stichococcus* were plasmolyzed, very few of the *Protoderma* cells showed any injurious effects.

The following is a list of the algae found in the cultures and the greatest depth at which they occurred:

<i>Protoderma viride</i> Kütz.	100 cm.
<i>Hantzschia amphioxys</i> (Ehr.) Grun.	100 cm.
<i>Navicula atemoides</i> Grun.	100 cm.
<i>Trochiscia</i> ?	80 cm.
<i>Stichococcus bacillaris</i> Nägeli.	70 cm.
<i>Oscillatoria amphibia</i> Agardh.	70 cm.
<i>Cladophora</i> sp.	60 cm.
<i>Ulothrix variabilis</i> Kütz.	60 cm.
<i>Anabaena</i> sp.	20 cm.
<i>Nitzschia Kütz.iana</i> Hilse.	20 cm.
<i>Nostoc muscorum</i> Agardh.	20 cm.
<i>Oscillatoria chlorina</i> Kütz.	20 cm.
<i>Oscillatoria subtilissima</i> Kütz.	20 cm.
<i>Scytonema Hofmanni</i> Agardh.	20 cm.
<i>Oscillatoria anoema</i> (Kütz.) Gomont.	Surface
<i>Oscillatoria formosa</i> Bory.	Surface
<i>Oscillatoria splendida</i> Greville.	Surface

ARTIFICIAL SUBTERRANEAN CULTURES

Very little work has been done on the effect of subterranean conditions upon the growth of algae. In studying the effect of light, culture media have been used which did not duplicate soil conditions. Esmarch determined the effect of light upon the growth of certain *Cyanophyceae* which he found in subterranean cultures. As shown above, these algae were grown on soil in the dark and examined from time to time. From his results, he concluded that these forms could live in darkness for a short period of time but after several weeks, in most cases, the cells showed effects due to the absence of light. The extent of this effect depended upon the nature of the soil and individual characteristics of the alga. Eventually only spores and heterocysts remained.

Since *Protoderma viride* was found to be universally present in the cultures, an attempt was made to determine the effect of subterranean conditions upon its growth. The foregoing results showed that it could exist in undisturbed soils for a depth of one meter at least, thus being capable of living for long periods of time in the absence of light. In order to determine the effect of these conditions upon its growth, the following experiments were performed:

One culture was set up January 15, 1919. A small amount of sterile clay was put into a sterile glass cylinder about 2 cm. in diameter and 1 m. long. The soil was moistened with sterile water and a piece of sterile filter-paper that had been inoculated with *Protoderma* derived from culture H9' was placed on top. Alternate layers of soil, moistened with water, and inoculated filter-paper were added until the tube was filled. A sterile cotton plug was used to cork the top, so that some aëration could take place. The tube was then sunk in the ground to the depth of 1 m., thus allowing the culture to grow under somewhat natural conditions. A flower-pot was placed over the top to protect the cotton plug.

Other cultures were set up on February 1, 1919. The actual aëration conditions occurring in the soil were more nearly duplicated in these than in the previous culture, since small sterile

cheese-cloth bags were filled with sterile clay soil which had been inoculated with *Protoderma* from culture HS'. These were placed in 6 sterile atmometer tubes which were then filled with sterile soil and enough sterile water to moisten. The tubes were corked and put in the ground at a depth of about 25 cm.

The tube in the first experiment was examined after about five months, on June 20, 1919, and *Protoderma* was found upon the filter-paper and also to some extent in the soil. Abundant growth was obtained in the part of the tube at the surface where some light had entered because the flower-pot did not at all times fit closely over the top. The rate of growth beneath the surface was much less, but even at a depth of 1 m. the algal cells were brilliantly green and healthy and had grown to some extent into the soil. This is comparable to the growth occurring under natural conditions, because in the soil samples taken algal growth was so scant that it could not be detected with the naked eye. In all cases the cells were either in plates or small and large single cells, some of which resembled *Protococcus*.

In the second experiment, the tubes were examined after different intervals of time. This method proved to be less satisfactory than the above due to the difficulty of finding the scattered algal cells among the soil particles. Thus, negative results would not necessarily mean that the algal cells had disintegrated.

Culture No.	Time examined	Interval	Result
1	Feb. 12, 1919	11 days	Some brown and colorless cells.
2	Feb. 18, 1919	17 days	No cells.
3	Feb. 24, 1919	23 days	Numerous green cells.
4	June 20, 1919	140 days	No cells.
5 and 6	June 27, 1919	147 days	Numerous green cells (2 tubes examined).

The above results agree with those in the first experiment. The fact that numerous *Protoderma* cells were found in the cul-

ture kept underground for the longest period of time would seem to indicate that the first culture examined was not a normal one. In cultures 2 and 4, the cells may have been overlooked, owing to the difficulty of finding them among the soil particles.

Since there is now in progress a detailed physiological study of *Protoderma* which will attempt to determine its possible function in the soil together with the influence of various environmental factors on its life history and growth, no reference to the literature nor further discussion of the problem need be given here. It is hoped that a subsequent paper on the subject may be published in the *Annals* within a short time.

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CULTURE EXPERIMENTS WITH MELAMPSORA IN JAPAN

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Culture experiments with the heteroecious rust *Melampsora* have been extensively undertaken by investigators in different countries, especially in Germany. However, owing to the diversity of local conditions and also the variability of the fungi themselves, the data which are secured in one country can not readily be accepted in others. The life histories of such heteroecious forms, therefore, require to be worked out for each country separately.

In the writer's first article ('15) of this study, the inter-relationships between the different spore types of a few species of *Melampsora* and the host species of *Salix* plants were for the first time reported in Japan. The life histories which have already been determined and reported by me are for the five species arranged in the following key:

KEY TO THE SPECIES

- A. Teleutospores subepidermal.
 - a. Teleutospores amphigenous and uredospores hypophyllous..... 1
Uredospores $15-20 \times 12-15 \mu$. Teleutospores $26-37 \times 8-13 \mu$.
On *Salix opaca* Anders.....1. *M. Larici-opaca* Miyabe and Matsumoto
 - b. Teleutospores and uredospores mostly hypophyllous..... 2
Uredospores $15-22 \times 12-16 \mu$. Teleutospores $18-40 \times 7-11 \mu$.
On *Salix Miyabeana* v. Seem.....
.....2. *M. Larici-Miyabeana* Miyabe and Matsumoto
- B. Teleutospores subepidermal, frequently subcuticular.
 - a. Teleutospores amphigenous, but mostly epiphyllous. Uredo-spores hypophyllous.....3, 4
Uredospores $13-19 \times 11-15 \mu$. Teleutospores $30-58 \times 8-13 \mu$.
On *Salix viminalis* L.....3. *M. Larici-epitea* Kleb.
Uredospores $14-18 \times 11-14 \mu$. Teleutospores $30-55 \times 8-14 \mu$.
On *Salix daphnoides* Vill.....4. *M. Larici-daphnoides* Kleb.
- C. Teleutospores subcuticular.
 - a. Teleutospores amphigenous, but mostly epiphyllous. Uredo-spores mostly hypophyllous, frequently amphigenous.....5
Uredospores $18-29 \times 12-16 \mu$. Teleutospores $20-30 \times 8-12 \mu$.
On *Salix jezoensis* v. Seem.....5. *M. jezoensis* Miyabe and Matsumoto

Since additional cultural results with *Melampsora* on species of *Salix* and *Populus* have been secured since the positive results in 1915, on the species mentioned above, supplementary notes are given later in the present paper.

MELAMPSORA ON SALIX URBANIANA V. SEEM.

In April, 1916, a large number of inoculations of *Larix decidua* with *Melampsora* obtained from *Salix Urbaniana* were undertaken for the purpose of verifying the results published in my earlier paper. Positive results were readily secured on *Larix decidua*, as shown in table I, while on the remaining species the inoculations were unsuccessful.

In May, 1916, several series of infection experiments were performed by the inoculation of *Salix Urbaniana* with the caeomaspores which had been produced on *Larix decidua*. After a week positive results were secured.

TABLE I
SHOWING THE RESULTS OF INOCULATION WITH MELAMPSORA
FROM SALIX URBANIANA

Inoculation material	Species inoculated	Date of inoculation	Result	Date of first sori
Teleutospores from				
<i>Salix Urbaniana</i>	<i>Larix decidua</i>	April 28	+	May 15
<i>Salix Urbaniana</i>	<i>Salix Urbaniana</i>	April 28	-
<i>Salix Urbaniana</i>	<i>Allium Cepa</i>	April 28	-
<i>Salix Urbaniana</i>	<i>Chelidonium majus</i>	April 28	-
Caeomaspores from				
<i>Larix decidua</i>	<i>Salix Urbaniana</i>	May 18	+	May 25

From the experiments it is evidently established that the species on *Salix Urbaniana* found in Sapporo, Japan, is heteroeccious and must have its aecidial stage on *Larix* sps. In consideration of the evidence given, as well as that which follows, I consider this a new species, and the accompanying diagnosis and notes are offered:

Melampsora Larici-Urbani Matsumoto, n. sp.

Aecidiospores. Caemata hypophyllous, scattered, pale orange-yellow with yellow spots on the upper surface, roundish



Fig. 1. *Melampsora Larici-Urbani*. Caemaspores. Camera lucida drawing $\times 460$.

or oblong; spores roundish or oval, finely echinate, $15-26 \times 13-19 \mu$; membrane hyaline, $3-4 \mu$ thick.

Uredospores. Sori hypophyllous, densely scattered over the whole lower surface, with yellow spots showing on the upper



Fig. 2. *Melampsora Larici-Urbani*. Uredospores. Camera lucida drawing $\times 460$.

surface, seated on small orange-yellow spots; spores mostly oval, sometimes oblong or roundish, with a more or less elongated stalk, $15-26 \times 12-17 \mu$; membrane hyaline, echinate, without perceptible germ pore; paraphyses capitate, with a thin pedicel ($3-4 \mu$), $50-70 \times 18-22 \mu$.

Teleutospores. Sori hypophyllous, dark reddish brown, scattered over the whole surface or confluent in excessive crusts, covered by the epidermis; spores prismatic, rounded at both

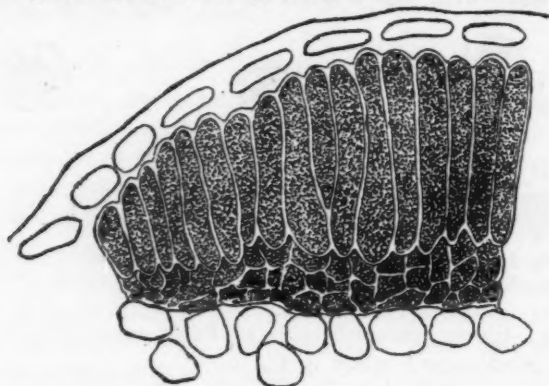


Fig. 3. *Melampsora Larici-Urbaniana*. Teleutospores. Camera lucida drawing $\times 460$.

ends, $38-70 \times 9-15 \mu$; membrane somewhat brown, uniformly thin, without an evident germ pore; contents orange-red; sporidia spherical, $9-15 \mu$.

Caeomata on *Larix decidua*; uredo- and teleutospores on *Salix Urbaniana*.

This species is more or less related to *Melampsora Larici-pentandrae* Kleb., as shown by the position of the teleutospore layer, by the thickness of the apical cell-wall, and by having the *Caeoma* stage on the leaves of *Larix* sps. On the other hand, there are characteristic differences, as follows: (1) The uredospore layer of the fungus in question is hypophyllous, while that of the other is epiphyllous; (2) The uredospores of our species are considerably shorter than the spores described by Klebahn ($26-44 \times 12-16 \mu$); (3) The teleutospores of our form are so decidedly larger that even the smallest can hardly be compared with the largest of the spores described by Klebahn ($28-38 \times 6-11 \mu$).

MELAMPSORA ON POPULUS BALSAMIFERA

As already stated in my previous paper, the author noticed an abundance of *Caeoma* on the leaves of *Chelidonium majus* at

Nakajima Park, Sapporo, where there were growing many species of *Populus* badly attacked by the *Melampsora* rusts. These indications, in the light of results obtained by Klebahn in Germany, induced me to assume that there might be some relationship between the *Caeoma* on *Chelidonium* and the *Melampsora* on some species of *Populus*. However, in the inoculation of *Chelidonium* with *Melampsora* from *Populus* (1915), no light could be thrown on this subject; therefore in the following year additional cultures were made, but these also failed to yield any positive results.

After these successive negative results, the writer made cultures with species of *Melampsora* from *Populus balsamifera* on *Larix leptolepis*, *Larix decidua*, *Ribes grossularia*, and *Allium Cepa*. A study of the data in table II shows that the sporidia of the rust on *Populus balsamifera* infect *Larix leptolepis* and *Larix decidua* without any apparent preference, while on the remaining plants they prove to be quite ineffective.

TABLE II
SHOWING THE RESULTS OF INOCULATIONS WITH MELAMPSORA
FROM POPULUS BALSAMIFERA

Inoculation material	Species inoculated	Date of inoculation	Result	Date of first sori
Teleutospores from				
<i>Populus balsamifera</i>	<i>Larix leptolepis</i>	May 2	+	May 18
<i>Populus balsamifera</i>	<i>Larix decidua</i>	May 2	+	May 19
<i>Populus balsamifera</i>	<i>Ribes grossularia</i>	May 2	-
<i>Populus balsamifera</i>	<i>Allium Cepa</i>	May 2	-
Caeomaspores from				
<i>Larix decidua</i>	<i>Populus balsamifera</i>	May 24	+	June 8

The species can properly be regarded as *Melampsora Larici-populina* Kleb. on account of the position of the uredo- and teleutospore layer and the relationship between the different spore forms and the host plants. The author observes some

difference in size between both the caeoma- and the teleutospores of species from the two sources, but these points alone are not sufficient to be considered as of specific importance.

The characterization of the species is as follows:

Melampsora Larici-populina Kleb.

Aecidiospores. Caeomata hypophyllous, single or in groups, with yellow spots on the upper surface, roundish or oblong, 1-1.5 mm. in diameter, orange-red, pulverous; spores roundish or oval, finely and densely verruculose, $22-37 \times 18-27 \mu$.

Uredospores. Sori mostly hypophyllous, seated on yellow spots, scattered over the whole surface, orange-yellow, pulverous; spores oval or elongated, $26-40 \times 16-22 \mu$; membrane hyaline, finely echinulate, without perceptible germ pore; paraphyses capitate, with a slender pedicel, $16-22 \times 55-80 \mu$.

Teleutospores. Sori epiphyllous, frequently hypophyllous, dark reddish brown, scattered or in groups over the whole surface, covered by the epidermis; spores cylindrical or somewhat wedge-shaped, $18-48 \times 8-12 \mu$; membrane clear brown, uniformly thin, without an evident germ pore; sporidia spherical.

Caeomata on *Larix leptolepis* and *Larix decidua*; uredo- and teleutospores on *Populus balsamifera*.

MELAMPSORA ON SALIX BABYLONICA

When negative results were obtained as to any relationship between Caeoma on *Chelidonium* and *Melampsora* on *Populus*, the author performed a new experiment by inoculating *Chelidonium majus* with teleutospore material obtained from several species of *Salix* and *Populus*.

As will be shown in the data of table III, successful results were only secured by sowing the teleutospore material obtained from *Salix babylonica*.

As may be easily seen, the species on *Salix babylonica* requires *Chelidonium majus* for complete development of its entire life cycle, but owing to the fact that no return infections to *Salix* sps. have been made, the subject has not yet been completely established.

The aecidial stage resulting from the successful inoculation

TABLE III
SHOWING THE RESULTS OF INOCULATIONS OF CHELIDONIUM
WITH TELEUTOSPORES

Inoculation material	Date of inoculation	Result	Date of first sori
Teleutospores from			
<i>Salix Capraea</i>	June 10	—
<i>Salix babylonica</i>	June 10	+	June 21
<i>Populus nigra</i>	June 10	—
<i>Populus balsamifera</i>	June 10	—

with the teleutospores obtained from *Salix babylonica* may be described as follows:

Acidiospores. Caeomata hypophyllous, clustered or isolated, with yellow spots on the upper surface, small, roundish; spores roundish or oblong, $14-18 \times 13-17 \mu$; membrane hyaline, finely verruculose.

MELAMPSORA ON SALIX CAPRAEA

From the fact that our Japanese *Melampsora* on *Salix Capraea* is morphologically more or less similar to *Melampsora Larici-Capraearum* described by Klebahn, the writer was inclined to assume that the first-named form might have its aecidial stage on *Larix* sps., consistent with the observations made in Germany.

In April, 1916, a large number of experiments were undertaken by inoculating *Larix decidua* with sporidia obtained from the teleutospore stage on *Salix Capraea*, but no successful result has been secured. According to von Tubeuf, successful results were obtained by sowing *Caeoma Abietis pectinatae* upon *Salix Capraea*. I have been unable to establish this relationship.

SUMMARY

1. A *Melampsora* on *Salix Urbaniana* requires *Larix* sps. for the completion of its life cycle. For this species the name *Melampsora Larici-Urbaniana* Matsumoto is proposed.

2. A *Melampsora* on *Populus balsamifera* found in Japan is identified with *Melampsora Larici-populina* described by Klebahn in Germany.

3. A *Melampsora* on *Salix babylonica* has its *Caeoma* stage on the leaves of *Chelidonium majus*. Owing to the lack of infection experiments with the alternate host the relationship has not yet been completely established.

4. A *Melampsora* on *Salix Capraea* seems to have a *Caeoma* stage neither on the leaves of *Larix* sps. nor *Abies* sps.

The author wishes to express here his heartiest thanks to Dr. K. Miyabe to whom he is indebted for many valuable suggestions, likewise to Dr. B. M. Duggar for his kindly advice and criticism. Thanks are also due Dr. G. T. Moore for the privileges of the library.

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